5. 40 CFR 122.21(r)(5) – COOLING WATER SYSTEM DATA

This section presents data on the LEC CWIS through which cooling water is withdrawn from LMOR.

5.1 COOLING WATER SYSTEM DESCRIPTION

The LEC cooling water intake structure withdraws water from the LMOR. The water is then returned to the river via a discharge canal. The LMOR flows from southwest to northeast at the LEC. Each of the four units withdraws circulating water through two separate pump bays. For a full description of the cooling water intake structure, see the LEC § 122.21(r)(3) report.

Each of the eight bays has a vertical, mixed-flow circulating water pump with impellors located approximately 25 feet downstream of the traveling water screens. At a normal water level of El. 455 feet, the total facility DIF is 1,448 MGD (2,240 cfs).

Approximately 97 percent of the intake flow is used for cooling. Eighty-five percent of the DIF is used for non-contact cooling and goes through the condensers. Twelve percent provides cooling for other systems including cooling water heat exchangers, condensate coolers, and jacket water coolers. A small portion of the water withdrawn by the circulating pumps, a maximum of 1 percent of the DIF, while on average approximately 0.5 percent of the DIF, is used to wash traveling water screens. The remaining portion of the water withdrawn by the circulating pumps is used for service water and other plant uses. A water balance diagram is provided in the LEC § 122.21(r)(3) section.

The cooling water is circulated through condensers for Units 1 and 2 and Units 3 and 4 to absorb heat from steam. Each unit has one condenser with two flow paths (an A and a B side). Just outside the facility wall, these two lines combine into one line for each unit/condenser. The four discharge lines run from the plant to the seal pit. The seal pit discharges over a weir and into 0.22-mile discharge canal designated as Outfall 001. The warmer water is discharged back into the Missouri River approximately 1,500 feet downstream of the intake structure. During winter, warm water from the seal pit is rerouted to a re-circulating pipe located between the trash racks and intake openings to prevent ice formation on the trash racks and screens.

Table 5-1 shows the monthly average river flow of the Missouri River from 2014 through 2018. The monthly average percent withdrawn from the Missouri River using the DIF ranged from 1.5 percent to 3.7 percent, with an annual average withdrawal rate of 2.3 percent for the five-year period. The percent withdrawal from the Missouri River using the corresponding average monthly withdrawal rate from 2014-2018 ranged from 1.3 percent to 3 percent with an annual average of 2 percent for the five-year period. Figure 5-1 shows the monthly percentages of water withdrawal at the LEC from 2014-2018.

Table 5-1 The LEC Cooling Water Intake Structure's Percent Withdrawal from the Missouri River.

Month	Monthly Average River Flow 2014 to 2018 (cfs)	Average Monthly Withdrawal Rate 2014-2018 (cfs)	Percent Withdrawal From the Missouri River (%)	
			DIF	Average Monthly Withdrawal Rate (2014-2018)
January	65,808	1,910	3.4%	2.9%
February	60,811	1,853	3.7%	3.0%
March	62,330	1,792	3.6%	2.9%
April	94,155	1,737	2.4%	1.8%
May	144,710	1,868	1.5%	1.3%
June	146,871	2,211	1.5%	1.5%
July	128,580	2,274	1.7%	1.8%
August	90,520	2,178	2.5%	2.4%
September	97,021	1,969	2.3%	2.0%
October	102,533	1,965	2.2%	1.9%
November	77,075	1,907	2.9%	2.5%
December	94,441	1,852	2.4%	2.0%
Average	97,307	1,961	2.3%	2.0%

Source: Ameren-Missouri Labadie Energy Center.
1 – River flow data were not available for January 21-22, 2016 and portions of January 20,2016, January 23, 2016, and February 10, 2016.

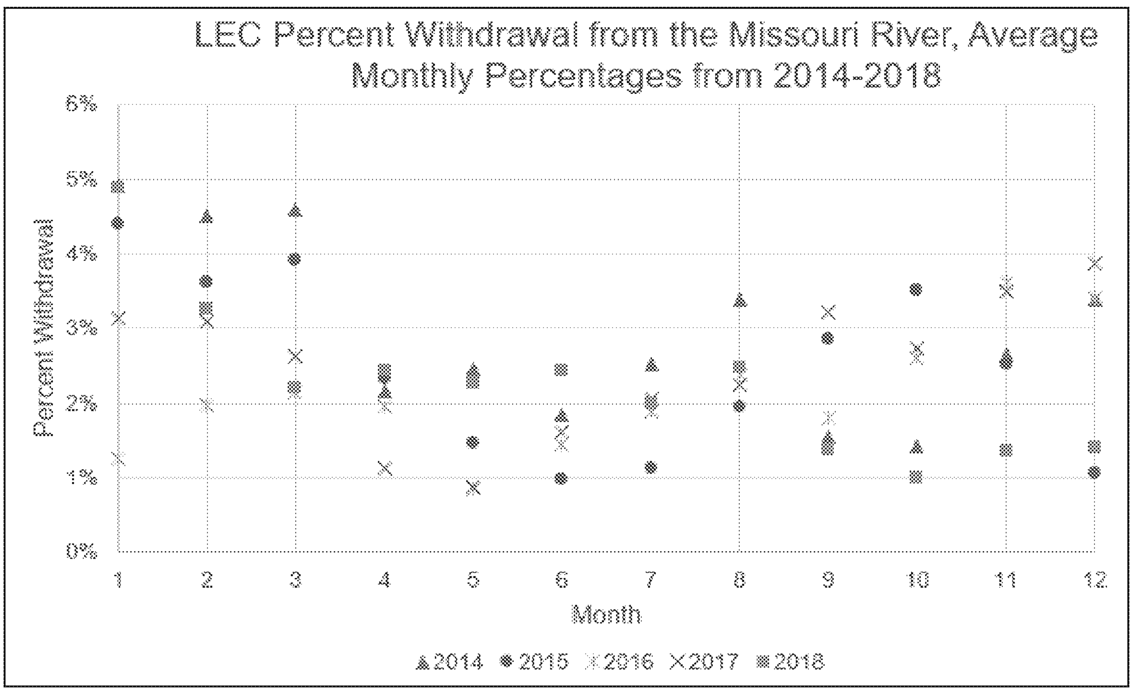


Figure 5-1 The LEC Monthly Percent Withdrawal from the Missouri River from 2014-2018.

5.2 COOLING WATER SYSTEM OPERATION

The average daily intake flow and AIF for the last 5 years (2014-2018) are provided in the LEC § 122.21(r)(3) report. An annual summary of operations is provided below in Table 5-2. Over this period, LEC used approximately 85 to 94 percent of its full DIF annually. The average monthly withdrawal rate, number of days per month, and total monthly withdrawal for the past 5 years (2014-2018) are provided in the LEC § 122.21(r)(3) report.

The LEC's cooling water system was operational every hour of every day of the 2014-2018 period. Individual unit outages occurred, and flow was reduced during those times. Individual unit cooling water pump operations are provided in Table 5-3 and unit cooling water operations are provided in

5.3 WATER REUSE, EFFICIENCIES, AND WITHDRAWAL REDUCTIONS

The LEC pumps are designed to provide the water needed to efficiently remove heat from condensers. In addition, during cooler months one or more pumps may be turned off to further reduce the water withdrawal rate (Table 5-4). There is no reuse of cooling water at the LEC, except for during winter periods when a portion of cooling water is rerouted from the discharge to a re-circulating pipe located between the trash racks and intake openings to prevent ice formation on the trash racks and screens.

Table 5-2 Estimated Actual Annual Intake Flow at the LEC (2014-2018).

	2014	2015	2016	2017	2018
Days per Year	365	365	366	365	365
Average Hours of Operation per Day	24	24	24	24	24
Design Intake Flow (MGD)	1,448				
Percent of Maximum Design Intake Flow	85%	94%	85%	87%	87%

Source: Ameren-Missouri Labadie Energy Center.

Table 5-3 Average Number of Days of Cooling Water System Operation by Unit at the LEC (2014-2018).

Month	Unit 1	Unit 2	Unit 3	Unit 4	Unit 1 - 4
January	31	31	31	31	31
February	28	28	28	28	28
March	31	31	28	26	31
April	30	25	20	24	30
May	30	20	28	28	31
June	30	29	30	30	30
July	31	31	31	31	31
August	31	31	31	31	31
September	25	30	26	30	30

Month	Unit 1	Unit 2	Unit 3	Unit 4	Unit 1 - 4
October	24	31	25	31	31
November	26	30	24	30	30
December	31	31	28	30	31
Annual Average	**348**	**348**	**329**	**351**	**365**

Source: Ameren-Missouri Labadie Energy Center.

5.4 WATER REUSE, EFFICIENCIES, AND WITHDRAWAL REDUCTIONS

The LEC pumps are designed to provide the water needed to efficiently remove heat from condensers. In addition, during cooler months one or more pumps may be turned off to further reduce the water withdrawal rate (Table 5-4). There is no reuse of cooling water at the LEC, except for during winter periods when a portion of cooling water is rerouted from the discharge to a re-circulating pipe located between the trash racks and intake openings to prevent ice formation on the trash racks and screens.

Table 5-4 Average Number of Days of Cooling Water System Operation by Pump at the LEC (2014-2018).

Month	Cooling Water Pump Days of Operation							
	1A	1B	2A	2B	3A	3B	4A	4B
January	25	28	31	21	27	30	31	29
February	28	19	22	25	19	28	26	28
March	30	24	30	29	19	26	26	26
April	29	29	25	24	17	18	24	22
May	29	28	19	20	28	26	27	26
June	29	30	26	28	29	29	30	30
July	30	31	31	30	31	30	31	31
August	28	30	30	30	30	30	31	30
September	22	21	28	29	24	25	30	29
October	24	23	31	31	25	24	31	31
November	22	26	30	30	24	21	28	27
December	29	29	31	26	27	19	21	24
Annual Average	**326**	**317**	**332**	**323**	**300**	**306**	**335**	**333**

Source: Ameren-Missouri Labadie Energy Center.

5.5 EXISTING IMPINGEMENT AND ENTRAINMENT REDUCTION MEASURES

Current impingement protection measures at the CWIS include 3/8-inch mesh traveling water screens with a combined debris and fish trough that allows for some survival of impinged fish when the screens are operating. The LEC does not currently use any technology or operational measures to reduce entrainment. The LEC § 122.21(r)(4) study provides additional information on the biological community in the vicinity of the CWIS. An evaluation of impingement mortality reduction technologies is provided in the LEC § 122.21(r)(6) study.

6 40 CFR 122.21(r)(6) – CHOSEN METHOD(S) OF COMPLIANCE WITH THE IMPINGEMENT MORTALITY STANDARD

This section provides an evaluation of the applicability and feasibility of each of the seven impingement mortality (IM) compliance alternatives identified in § 125.94(c)(1) – (7) for the LEC.

The background information necessary to make the IM BTA determination is provided in the following §122.21(r) studies that are included in this permit submittal:

§ 122.21(r)(2) – Source Water Physical Data

§ 122.21(r)(3) – Cooling Water Intake Structure Data

§ 122.21(r)(4) – Source Water Baseline Biological Characterization Data

§ 122.21(r)(5) – Cooling Water System Data

§ 122.21(r)(7) – Entrainment Performance Studies

§ 122.21(r)(8) – Operational Status

This Report is organized into two sections as follows:

- Site-specific Evaluation of the Seven IM Compliance Alternatives;
- LEC Compliance Alternative Selection

6.1 EVALUATION OF THE SEVEN IM COMPLIANCE ALTERNATIVES FOR THE LEC

6.1.1 COMPLIANCE ALTERNATIVE 1: OPERATE A CLOSED-CYCLE RECIRCULATING SYSTEM AS DEFINED AT § 125.92

The LEC consists of four coal-fired generating units which utilize once-through cooling to remove waste heat. Burns and McDonnell evaluated closed-cycle cooling technologies in a 2018 study (B&M 2018) to investigate thermal reduction technologies. B&M (2018) conducted a screening analysis regarding closed-cycle technologies and identified counter flow, film fill, mechanical draft cooling towers as the most feasible, implementable in scale and the most cost-effective cooling tower arrangement at the LEC when compared to the other cooling tower alternatives. The cooling tower array includes four new 480 ft. long, 88 ft. wide, and 52 ft. tall cooling towers. Eight new 4,200-horsepower (HP) pumps would be required in the cooling tower pump structure. Because the preliminary design provides make-up water from collector (Ranney) wells, the existing CWIS would not be needed and could be decommissioned after further evaluation.

Based on this configuration, the total project cost to retrofit the LEC with mechanical draft cooling towers is estimated to be approximately $432 million in 2019 dollars with annual O&M costs estimated at approximately $15 million. A more detailed analysis of closed-cycle cooling options and cost estimates for the LEC are available in the *§ 122.21 (r)(10) Comprehensive Technical Feasibility and Cost Evaluation Study* for determining entrainment BTA.

The total project and annual O&M costs associated with a closed-cycle retrofit at the LEC are significantly greater than what Ameren would incur using other IM compliance alternatives (Sections 6.1.2 – 6.1.5). In addition, the USEPA meant for this Compliance Alternative to apply to facilities that already utilize closed-cycle cooling and did not anticipate that presently once-through facilities would retrofit to closed-cycle for impingement compliance alone (USEPA 2014). Therefore, Ameren has not chosen Compliance Alternative 1 as its IM compliance option.

6.1.2 COMPLIANCE ALTERNATIVE 2: OPERATE A COOLING WATER INTAKE STRUCTURE THAT HAS A MAXIMUM THROUGH-SCREEN DESIGN INTAKE VELOCITY OF 0.5 FPS

The Ameren LEC CWIS is comprised of eight circulating water pumps each with an intake bay that has a trash rack and a traveling screen in front of the circulating water pump. At the design low water level (DLWL) (El. 450 ft), the calculated through-screen velocity is 1.96 fps. At mean low water (El. 455 ft), the DIF is 1,448 MGD and the calculated through-screen velocity is 1.67 fps. This information is presented in §122.21(r)(3). Reducing the design velocity through the existing screens to 0.5 fps would require a substantial reduction in the circulating water flow which is not feasible given the LEC's current operational needs. Based on the existing CWIS configuration and through-screen velocities, Alternative 2 is not applicable to LEC.

Modification of the CWIS by either expansion or installation of wedge-wire screens are two alternatives that could be used to reduce the design through-screen velocities to less than 0.5 fps. These alternatives were evaluated in § 122.21(r)(10) as part of the entrainment compliance technology evaluations. Wedge-wire screens were considered infeasible at the LEC due to the amount of space required and potential interference with navigation as well as the substantial potential for fouling. Intake expansion to accommodate 14, 12-foot wide traveling water screens with 0.5 mm mesh and a through screen velocity of 1.67 fps was estimated to cost at least $48 million. Preliminary calculations for an intake expansion to accommodate coarse mesh traveling water screens with a through screen velocity of 0.5 fps show that approximately 25 traveling water screens would be needed. Therefore, the cost to reduce the through screen velocity is likely to be in the range of $75 to $100 million (based on an approximate per screen installation cost of $3 to $4 M) with annual O&M costs in the range of $0.5 to 0.75 million. Based on the infeasibility of wedge-wire screens and the excessive cost of expanding the intake to reduce the through screen velocity to less than 0.5 fps, Compliance Alternative 2 was not chosen as the IM compliance option at the LEC.

6.1.3 COMPLIANCE ALTERNATIVE 3: OPERATE A COOLING WATER INTAKE STRUCTURE THAT HAS A MAXIMUM THROUGH-SCREEN INTAKE VELOCITY OF 0.5 FPS

This Compliance Alternative requires the facility to monitor the water withdrawal rate, water depth and screen clogging, and estimate the *actual* through-screen velocity on a continuous basis. This is intended for facilities with actual water depths significantly higher than the design low water depth; the benefit of the greater water depth would help the facility achieve lower than 0.5 fps through-screen velocity under most ambient conditions. If water depth is low, then the facility would reduce its water withdrawal rate to maintain through-screen velocity at or lower than 0.5 fps. However, the LEC's configuration is not conducive to this Compliance Alternative. If the LEC were to select this Compliance Alternative, it would incur capital costs similar to Compliance Alternative 2 but would incur monitoring costs significantly higher than Compliance Alternative 2. Therefore, Compliance Alternative 3 was not chosen as the IM compliance option at the LEC.

6.1.4 COMPLIANCE ALTERNATIVE 4: OPERATE AN OFFSHORE VELOCITY CAP AS DEFINED AT § 125.92 THAT IS INSTALLED BEFORE OCTOBER 14, 2014

The LEC does not have an offshore velocity cap and did not have one when the rule became effective, therefore Compliance Alternative 4 is not applicable.

6.1.5 COMPLIANCE ALTERNATIVE 5: OPERATE A MODIFIED TRAVELING SCREEN (BTA) THAT THE DIRECTOR DETERMINES MEETS THE DEFINITION AT § 125.92(S) AND THAT THE DIRECTOR DETERMINES IS THE BEST TECHNOLOGY AVAILABLE FOR IMPINGEMENT REDUCTION

The eight existing traveling water screens at the LEC could be replaced with coarse-mesh, modified traveling water screens and a fish return system. The new modified screens would incorporate fish-friendly features identified in the § 316(b) regulations, including:

- Collection buckets (or equivalent) to minimize turbulence to aquatic life;
- Screen panel materials such as smooth woven mesh, drilled mesh, molded mesh, or similar materials to protect fish from descaling;
- Continuous or near-continuous rotation of screens and operation of collection equipment to recover impinged fish as soon as practical;
- Low pressure wash or vacuum to remove collected organisms from the screens prior to any high-pressure spray wash to remove debris from the screens;
- Fish handling and return systems with sufficient water flow to return fish directly to the source water in a manner that does not promote predation or the re-impingement of the fish, or a large vertical drop.

Replacing the existing screens including new spraywash pumps, control systems, and a fish return system is expected to cost approximately $14 to $16 million (in 2019 dollars) based on budget level cost estimates (B&V 2016). Black and Veatch (B&V 2016) provided a conceptual screen replacement and fish return design and assumed a four-year installation schedule which did not account for final design, permitting, and procurement. Accounting for these elements would likely result in an approximately six-year design, permitting, and installation schedule. Under this compliance option, a 2-year optimization study would be required to demonstrate compliance with this alternative. Ameren assumes that the optimization study would commence after all screens have been replaced with fish-friendly screens.

The use of coarse-mesh, modified traveling water screens with a fish return system is an IM compliance option that could potentially be implemented at the LEC and is Ameren's preferred IM compliance option.

The § 122.21(r)(10) report evaluates two fine-mesh traveling water screen options: 2-mm dual flow screens in the existing intake and 0.5-mm mesh thru-flow screens in an expanded intake. Those two options could meet the definition at §125.92(s). However, both those options introduce significant uncertainty with construction and operations and are therefore, not practical for IM compliance at the LEC.

6.1.6 COMPLIANCE ALTERNATIVE 6: OPERATE ANY OTHER COMBINATION OF TECHNOLOGIES, MANAGEMENT PRACTICES AND OPERATIONAL MEASURES THAT THE DIRECTOR DETERMINES IS THE BEST TECHNOLOGY AVAILABLE FOR IMPINGEMENT REDUCTION

Compliance Alternative 6 provides a facility the flexibility to achieve IM compliance through the cumulative effect of a system of technologies and/or management and operational controls. A preliminary screening of potential options to apply Compliance Alternative 6 (such as flow reduction measures, variable frequency drives, barrier nets, louvers, and various behavioral deterrents), indicates that this alternative is not practical at the LEC.

Operating as a baseload facility, the LEC cannot substantially alter its operating regime such that it would appreciably reduce impingement. Accordingly, management and operational measures aimed at reducing load are not feasible at the LEC. Similarly, technology such as variable frequency drives that would reduce power generation and therefore water withdrawal are not practical at the LEC. Technologies designed to exclude organisms from being impinged or reduce the number of organisms impinged such as barrier nets and louvers are deemed not feasible at the LEC due to proximity of the navigation channel to the CWIS and the substantial debris load present in the Missouri River. Wedge-wire screens were evaluated in the § 122.21(r)(10) report and were deemed to be not feasible for similar reasons. Other technologies such as bubble curtains, electrical fields, acoustic deterrents, and light/sound systems do not have a record of proven effectiveness and therefore would not likely reduce IM enough to achieve compliance and are not considered for the LEC.

Based on the results of the preliminary screening, Compliance Alternative 6 was not chosen as the IM compliance option for the LEC.

6.1.7 COMPLIANCE ALTERNATIVE 7: ACHIEVE THE SPECIFIED IMPINGEMENT MORTALITY PERFORMANCE STANDARD

Compliance Alternative 7 requires achieving annual IM of 24 percent for non-fragile species verified by ongoing monthly latent IM monitoring. Failure to meet the 24 percent annual IM criterion would result in a reportable non-compliance with the NPDES permit and potentially subject Ameren to fines and penalties. Given the substantial monitoring requirements and continual risk of non-compliance, Compliance Alternative 7 was not chosen as the IM compliance option for the LEC.

6.1.8 OTHER IM COMPLIANCE CONSIDERATIONS

EPA provided two additional IM compliance options that apply under rare circumstances. These are the *de minimis* rate of impingement and low capacity utilization power generating units.

Impingement monitoring at the LEC was conducted over a one-year period from July 2005 to July 2006. A total of 6,972 fish weighing 72.2 kg was collected over the one-year study period and total annual impingement was estimated to have been 100,926 fish with an estimated biomass of 1,143 kg. Additional information on the LEC impingement program is provided in the § 122.21(r)(4) report. This level of impingement is expected to exceed the requirement for a *de minimis* determination at the site.

As reported in § 122.21(r)(8), the average annual capacity utilization rate for the four LEC Units from 2014-2018 was 73.6 percent. This utilization rate exceeds the 8 percent threshold.

Neither of these two alternative methods to demonstrate compliance is applicable to the LEC.

6.2 LEC COMPLIANCE ALTERNATIVE SELECTION

As required by the Rule, Ameren must inform the Director of its chosen method of compliance for achieving BTA for IM. After careful review and evaluation of the seven IM compliance alternatives, Compliance Alternative 5 (modified traveling screens and fish return system) has been chosen as the IM BTA for the LEC. If the MDNR determines that existing design and operational measures are BTA for entrainment, impingement BTA compliance will be met by replacing the LEC's existing conventional traveling water screens with coarse-mesh modified-traveling water screens and a fish return system as described in Section 6.1.5.

However, since the LEC is also subject to the site-specific entrainment requirements along with additional study requirements set forth in § 122.21(r)(1)(ii)(B) and consistent with the § 316(b) Rule, the final selection of an IM BTA compliance is deferred until after the MDNR makes the entrainment BTA determination. At that time, Ameren will submit its final chosen method of compliance for IM reduction BTA, along with its implementation schedule.

6.3 REFERENCES

Black & Veatch Corporation (B&V). 2016. Ameren Fine Mesh Screen Evaluations and Conceptual Cost Estimate for the Labadie, Rush Island, and Sioux Power Plants, dated November 4, 2016. Technical Memorandum Submitted to Ameren Corporation.

Burns & McDonnell, Inc. (B&M). 2018. Ameren Labadie Energy Center Thermal Discharge Best Available Technology Economically Achievable Analysis. Report Submitted to Ameren Corporation.

United States Environmental Protection Agency (USEPA). 2014. National Pollution Discharge Elimination System – Final Regulations to Establish Requirements for Cooling Water Intake Structures at Existing Facilities and Amend Requirements at Phase I Facilities. 40 CFR Parts 122 and 125. Federal Register Vol. 79, No. 158.

7. 40 CFR 122.21(r)(7) – ENTRAINMENT PERFORMANCE STUDIES

This section identifies any technologies currently being used by the LEC to reduce entrainment and their efficacy and summarizes any studies that address entrainment and/or through-facility entrainment survival at the LEC.

7.1 EXISTING ENTRAINMENT TECHNOLOGY

Ameren currently does not employ any entrainment reduction technologies at the LEC. Entrainment survival studies have not been conducted. Thus, entrainment mortality at the LEC is assumed to be 100 percent. In addition, as a baseload facility typically operating above 85 percent of capacity, the LEC does not claim any flow-related entrainment reduction.

7.2 ENTRAINMENT STUDIES

Two entrainment characterization studies have been conducted at the LEC. An initial study was performed during 1974 and 1975 to identify those organism's in the facility's vicinity that might be susceptible to entrainment and to determine the potential effects of entrainment should any exist (EEHI 1976). The most recent study was conducted over two years during 2015 and 2016 to meet the requirements imposed under § 122.21(r)(9).

The composition of entrained ichthyoplankton at the LEC has changed considerably in the intervening 40 years since the original study was conducted, particularly as Asian carps have successfully invaded the LMOR during the last decade (Wanner and Klumb 2009). Thus, the 1974 – 1975 study is no longer considered to be relevant and representative of conditions at the facility. The 2015 – 2016 study was conducted within the last ten years and is representative of entrainment at the LEC.

Major findings from the 2015 – 2016 entrainment study include:

- The period of peak entrainment occurred from mid-May to early or mid-June.
- Larvae of invasive Asian carps, including bighead carp (*Hypophthalmichthys nobilis*), silver carp (*Hypophthalmichthys molitrix*), and grass carp (*Ctenopharyngodon idella*), accounted for 85.4 percent of all larvae collected during the 2015 – 2016 study.
- No significant differences in entrainment density were observed among diel sampling intervals during 2015 and 2016 when combining all taxa together or within major groups.

Detailed methods and results for the 2015 – 2016 site-specific entrainment sampling conducted at the LEC can be found in the *§ 122.21(r)(9) Entrainment Characterization Study* report. Relevant taxa and a discussion of their susceptibility to entrainment at the LEC CWIS based on distribution, life history and site-specific characteristics are discussed in more detail in the *§ 122.21(r)(4) Source Water Baseline Biological Characterization Data* study.

7.3 SUMMARY

No entrainment reduction technologies are in use currently at the LEC and through-facility mortality is assumed to be 100 percent. An entrainment characterization study meeting the § 122.21(r)(9) requirements was conducted at the LEC during 2015 and 2016. Data from this study are recent and considered relevant and representative of current conditions at the facility. The methodology and results of this study are presented in detail in the *§ 122.21(r)(9) Entrainment Characterization Study* submittal report.

7.4 REFERENCES

Equitable Environmental Health, Inc. (EEHI). 1976. Labadie Power Plant Entrainment and Impingement Effects on Biological Populations of the Missouri River. Prepared for Union Electric Company, St. Louis, Missouri. July 1976. 81 pp. plus 8 appendices.

Wanner, G.A., and R.A. Klumb. 2009. Asian Carp in the Missouri River: Analysis from Multiple Missouri River Habitat and Fisheries Programs. National Invasive Species Council materials. Paper 10.

8. 40 CFR 122.21(r)(8) – OPERATIONAL STATUS

The LEC has four coal-fired generating units with a total gross winter generating capacity of 2,580 MW. In the summer, the total gross generating capacity decreases to 2,488 MW.

Table 8-1 Operation Details for Each Unit at the LEC.

	Unit 1	Unit 2	Unit 3	Unit 4	Total
Commission Year	1970	1971	1972	1973	-
Status	Operational	Operational	Operational	Operational	-
Gross Rating (January), MW	645	645	645	645	2,580
Gross Rating (July/August), MW	622	622	622	622	2,488

Source: Ameren-Missouri Labadie Energy Center, 2018.

8.1 OPERATIONAL STATUS DESCRIPTION

The Rule requires facilities to include generation data and capacity utilization for the previous five years. The monthly gross generation and capacity ratings for Units 1-4 from 2014-2018 are provided in Table 8-2 and Table 8-3, respectively.

Table 8-2 Monthly Gross Capacity Rating for each Unit at the LEC.

Month	Units	Each Unit (1-4)	Total
January	MW	645	2,580
February	MW	644	2,576
March	MW	643	2,572
April	MW	640	2,560
May	MW	635	2,540
June	MW	627	2,508
July	MW	622	2,488
August	MW	622	2,488
September	MW	629	2,516
October	MW	636	2,544
November	MW	643	2,572
December	MW	644	2,576

Table 8-3 Average Total Gross Monthly Generation (MWhrs), 2014-2018.

	Units	Unit 1	Unit 2	Unit 3	Unit 4	Station Total
January	MWhrs	414,982	414,912	367,552	403,290	1,600,736
February	MWhrs	376,050	355,171	339,228	321,284	1,391,733
March	MWhrs	358,888	340,189	273,416	311,933	1,284,426
April	MWhrs	361,052	307,108	206,901	272,066	1,147,128
May	MWhrs	321,464	247,289	304,254	291,027	1,164,034
June	MWhrs	362,047	334,054	342,506	357,124	1,395,730
July	MWhrs	403,381	399,476	385,455	401,823	1,590,134
August	MWhrs	388,102	385,837	361,437	383,282	1,518,658
September	MWhrs	254,406	351,398	269,857	356,597	1,232,258
October	MWhrs	281,401	387,901	274,622	397,718	1,341,641
November	MWhrs	301,944	370,485	274,884	383,253	1,330,566
December	MWhrs	379,799	380,865	271,521	363,665	1,395,850
Annual Average	MWhrs	4,203,515	4,274,685	3,671,634	4,243,062	16,392,896

Source: Ameren-Missouri Labadie Energy Center, 2019.

The capacity factors represent the ratio of actual average monthly generation to the maximum potential monthly generation if the station operated at full capacity for the entire month. The monthly capacity factors for each unit are shown in Table 8-4.

Table 8-4 Average Monthly Capacity Factors (%), 2014-2018.

Month	Units	Unit 1	Unit 2	Unit 3	Unit 4	Station Total
January	%	86.5	86.5	76.6	84.0	83.4
February	%	86.9	82.1	78.4	74.2	80.4
March	%	75.0	71.1	57.2	65.2	67.1
April	%	78.4	66.6	44.9	59.0	62.2
May	%	68.0	52.3	64.4	61.6	61.6
June	%	80.2	74.0	75.9	79.1	77.3
July	%	87.2	86.3	83.3	86.8	85.9
August	%	83.9	83.4	78.1	82.8	82.0
September	%	56.2	77.6	59.6	78.7	68.0
October	%	59.5	82.0	58.0	84.1	70.9
November	%	65.2	80.0	59.4	82.8	71.9
December	%	79.3	79.5	56.7	75.9	72.8
Average Annual Capacity Factor, 2014-2018	%	75.5	76.8	65.9	76.2	73.6

Source: Ameren-Missouri Labadie Energy Center, 2019.

8.2 GENERATING UNIT OUTAGES

A summary of the major extended outages at the LEC in the last five years (2014-2018) is provided in Table 8-5. Additional minor outages of 10 days or less also occurred during this period but are not listed here.

Table 8-5. Summary of Extended Outages, 2014-2018.

Year	Dates	Unit	Number of Days
2014	4/2 to 6/5	Unit 2	65
	9/5 to 12/5	Unit 1	92
2015	3/27 to 5/19	Unit 3	54
2016	3/5 to 5/24	Unit 4	81
	5/6 to 6/7	Unit 2	33
	9/20 to 10/12	Unit 1	23
2017	3/10 to 4/30	Unit 3	52
2018	3/16 to 3/24	Unit 2	9
	8/31 to 12/21	Unit 3	113

8.3 NON-POWER UNITS USING COOLING WATER

The LEC currently has no non-power generating units in operation that withdraw cooling water from the Missouri River.

8.4 MAJOR UPGRADES

The LEC has not completed any major projects that would impact water withdrawal in the last 15 years. The LEC has, throughout its operating history, undertaken numerous repairs, maintenance, and efficiency improvement projects on each of the operating units.

8.5 NEW UNIT PLANS AND SCHEDULE

No new units are currently planned at the LEC. It is anticipated that the generation schedules provided from 2014-2018 are representative of future operations.

9. 40 CFR 122.21(r)(9) – ENTRAINMENT CHARACTERIZATION STUDY

An entrainment characterization study was conducted at the LEC during 2015 and 2016 using appropriate sampling, quality assurance, and analysis procedures to characterize annual, seasonal, and diel variability in entrainment of fishes of all life stages at the facility.

Entrainment sampling and environmental data collection was performed by Amec Foster Wheeler Environment & Infrastructure, Inc. (Amec) in St. Louis, MO, which is now Wood Environment and Infrastructure Solutions, Inc. (Wood).

9.1 STUDY METHODOLOGY

9.1.1 Entrainment Sampling

Entrainment sampling at the LEC was performed at the discharge seal well (Figure 9-1) to ensure the collection of samples which were representative of entrainment at the facility as organisms collected were in fact entrained, which was a limitation of past sampling performed in front of the intake during 1974-1975 (EEHI 1976a). The seal well was an accessible location equipped with guard rails to provide a safe sampling site for field crews away from normal facility operations. Furthermore, sampling at the discharge eliminates concerns about vertical stratification of organisms in the water column as discharge water is thoroughly mixed with regard to ichthyoplankton densities (NYU 1978; Jude et al 1986; EA 1979, 1981). Potential mechanical destruction of the entrained organisms as they pass through the pumps and cooling water system does not create a significant source of bias (NYU 1978, EA 1981, Cada et al. 1981, EPRI 2009). Thus, by sampling entrained organisms in well-mixed cooling water drawn from all depths at the CWIS, the data collection site accounted for the location of the CWIS in the waterbody and water column.

Entrainment sampling was conducted weekly from March through September during both study years to coincide with the period when entrainment of fish eggs and larvae was most likely to occur. Samples were collected approximately every 6 hours over each 24-hour sampling event to correspond with the following sampling time intervals: 00:00-06:00, 06:00-12:00, 12:00-18:00, and 18:00-24:00 hours. The sampling apparatus consisted of a pump-and-net barrel sampler (Figure 9-1) fitted with a conical 335-micrometer (μm) mesh ichthyoplankton net to collect specimens and an inline flow meter to estimate the volume of water filtered. Sample water was withdrawn from the seal well through a 4-inch flex tube connected to a gasoline-powered Honda 4-in. trash pump and rigid 4-in. piping fixed to the sampling barrel. Care was taken to minimize damage to entrained organisms by using a trash pump with a recessed impeller and throttling flow rates during sampling to approximately 1 m^3 per minute. A minimum sample volume of 100 m^3 was targeted.

Ancillary measurements of ambient river water quality, including temperature, DO, and conductivity, were measured near the CWIS at the beginning and end of each sample collection by lowering a pre-calibrated YSI meter probe in front of the trash racks. Additional river condition data measured at the LEC and Hermann gages, such as temperature, gage height, and discharge, were acquired using the USGS National Water Information System Website (USGS 2018). Facility operation data, including hourly cooling water flows estimated during the study period, were provided by Ameren.

The 2015 study year was conducted over 30 sampling events from 3 March to 22 September, whereas the 2016 study year was conducted over 31 sampling events from 1 March to 27 September (Table 9-1). Samples were collected during all planned time intervals and total volumes sampled during each event were consistent, ranging from 407 to 428 m^3 across both study years. Operations at the LEC were normal throughout both study years.

9.1.2 River Sampling Near CWIS

Ichthyoplankton sampling in the Missouri River near the LEC CWIS was appended to the original study design midway through the 2015 study year to aid with the taxonomic identification of specimens collected in entrainment samples. Ichthyoplankton sampling upstream of the CWIS was conducted weekly on the same day as entrainment sampling during daytime between 06:00 and 18:00 hours with sampling occurring from 30 June to 22 September in 2015 and from 5 April to 27 September in 2016. Each collection consisted of two near-surface and two near-bottom tows using a 1-meter conical ichthyoplankton net with 500-µm mesh equipped with a removable cod end. A General Oceanics flowmeter was suspended in the mouth of the net to estimate sample volumes with 50 m^3 targeted per tow.

The purpose of the river sampling was to aid in the taxonomic identification of specimens collected at the discharge. Results of these collections are reported in Table A-4 of Appendix 9 A.

Figure 9-1 Entrainment Sampling at the LEC Discharge Seal Well Using the Pump-and-Barrel Sampling Apparatus.

ED_005618_00000110-00019

Table 9-1 Summary of 2015 and 2016 Sampling Events Conducted for the Entrainment Characterization Study at the LEC Discharge.

2015 Study Year				2016 Study Year			
Sampling Event	Sampling Dates	No. of Samples	Total Volume Sampled (m^3)	Sampling Event	Sampling Dates	No. of Samples	Total Volume Sampled (m^3)
1	03-03	4	420.3	31	03-01, 03-02	4	408.5
2	03-10	4	422.6	32	03-08, 03-09	4	409.9
3	03-17	4	419.2	33	03-15, 03-16	4	409.2
4	03-24	4	428.0	34	03-22, 03-23	4	409.2
5	03-31	4	418.7	35	03-29, 03-30	4	409.3
6	04-07	4	414.3	36	04-05, 04-06	4	415.5
7	04-14	4	415.7	37	04-12, 04-13	4	414.6
8	04-21	4	415.8	38	04-19, 04-20	4	410.0
9	04-28	4	410.2	39	04-26, 04-27	4	412.5
10	05-05	4	412.7	40	05-03, 05-04	4	412.1
11	05-12	4	415.2	41	05-10, 05-11	4	413.6
12	05-19	4	414.1	42	05-17, 05-18	4	411.1
13	05-26	4	413.4	43	05-24, 05-25	4	409.8
14	06-02	4	409.2	44	05-31, 06-01	4	410.0
15	06-09	4	407.1	45	06-07, 06-08	4	411.5
16	06-16	4	408.6	46	06-14, 06-15	4	412.9
17	06-23	4	413.1	47	06-21, 06-22	4	420.7
18	06-30	4	410.3	48	06-28, 06-29	4	408.2
19	07-07	4	409.8	49	07-05, 07-06	4	409.7
20	07-14	4	410.1	50	07-12, 07-13	4	407.0
21	07-21	4	410.4	51	07-19, 07-20	4	408.4
22	07-28	4	410.9	52	07-26, 07-27	4	410.3
23	08-04	4	409.4	53	08-02, 08-03	4	411.4
24	08-11	4	419.0	54	08-09, 08-10	4	409.6
25	08-18	4	408.6	55	08-16, 08-17	4	412.4
26	08-25	4	415.9	56	08-23, 08-24	4	409.0
27	09-01	4	411.8	57	08-30, 08-31	4	408.0
28	09-08	4	412.5	58	09-06, 09-07	4	409.2
29	09-15	4	416.1	59	09-13, 09-14	4	410.4
30	09-22	4	410.1	60	09-20, 09-21	4	409.1
				61	09-27, 09-28	4	408.8

9.1.3 Laboratory Analysis

Entrainment and river ichthyoplankton samples were processed at Wood's Ecology Laboratory in St. Louis, MO according to the standard operating procedures (SOP) set forth by Amec (2016).

Contents of each sample were thoroughly rinsed into a No. 50 size sieve having 300-μm mesh. All fish eggs, larvae and juveniles were sorted from the sample using a 10X magnifying lamp and submitted for taxonomic analysis. If samples contained a large number of specimens or large amounts of detritus, samples were split using a Folsom plankton splitter. Sub-samples were then processed until a minimum of 200 specimens were found. Counts for individual sub-samples were maintained in the event that multiple sub-samples were required to reach a total of 200 specimens or in the event that an initial sub-sample containing more than 200 specimens was split a second time. The remainder of the sub-samples were also examined for the presence of potential endangered pallid sturgeon (*Scaphirhynchus albus*) specimens.

All taxonomic identifications were made by trained Wood personnel familiar with native and non-native fish species in Missouri. Identifications were made using a stereomicroscope with a polarized light set-up. Specimens were identified to stages of development, including egg, YSL, PYSL, juvenile, and small adults. Larval specimens that could not be reliably assigned to a development stage due to physical damage were simply categorized as larvae (LAR). During the 2015 study year, only eggs of freshwater drum could be reliably identified to a taxonomic group due to the presence of a large posterior oil globule and all other eggs were designated as belonging to an "unknown" taxonomic category. The taxonomic identification approach was further refined in 2016 to allow for the identification of Asian carp eggs based on their relatively large size (4.9-6.0 mm) and large perivitelline space (personal communication, Matthew Basler, Senior Fisheries and Wildlife Biologist, Wood). Up to 30 specimens per sample of each taxon and life stage (excluding eggs) were measured to the nearest 0.1 mm.

Damaged or partial specimens were counted as part of the sample to avoid negative bias following the convention of only counting specimens that consist of at least two thirds of their body. All identifications were made to the lowest practical taxonomic level using well-recognized taxonomic references for larval fishes (Hogue et al. 1976; USFWS 1978; Auer 1982; Fuiman et al. 1983; ES&E 1985a, 1985b; Holland-Bartels et al. 1990; Wallus et al. 1990, 1994; Snyder 2002; Wallus et al. 2004; Chapman 2006; Wallus et al. 1990-2008). The relatively undamaged specimens from river ichthyoplankton sampling in the source waterbody were used to support the taxonomic certainty of specimens from entrainment samples. Larval specimens in the carp and minnow family Cyprinidae that could not be identified to species were placed into six groupings based on four morphological characters including relative preanal length, eye shape, preanal myomere number, and midventral pigmentation according to Fuiman et al. (1983). Species belonging to each of the six Cyprinidae family groupings were known to occur in the LMOR near the LEC (Table 9-2) based on a review of the biological community summarized in the *§ 122.21(r)(4) Source Water Baseline Characterization Data* submittal report. All fish species known to occur in the LMOR in the vicinity of the LEC based on past and recent sampling are listed in Table A-1 in Appendix 9 A along with relevant taxonomic information including scientific names and family associations.

Protocols were prepared in the event that state or federally protected species were identified among collected specimens, however no such instances occurred during either year of sampling. Specimens tentatively identified as potentially being a protected species were to be photographed for documentation along with detailed capture information and were to be examined by an independent, recognized taxonomic expert to verify their identification. Specimens confirmed as state-listed "special concern", "threatened", or "endangered" species were to be reported to the MDC in compliance with conditions of the Missouri Wildlife Collector's Permit. Similarly, the USFWS was to be notified following identification of any federal threatened or endangered species (e.g., pallid sturgeon) to determine what subsequent actions were to be taken.

Table 9-2 Species Belonging to Carp and Minnow Family Groups Identified by Distinct Morphological Characters (Fuiman et al. 1983) Known to Occur near the LEC.

Minnow Family Group	Distinctive Larval Character	Fish Common Name	
Group 1	High preanal length	Goldfish Common carp	Grass carp
Group 2	Flattened eye	Silver chub Bluntnose minnow Shoal chub[1]	Sand shiner Suckermouth minnow Bullhead minnow
Group 3	High preanal myomere number (>25)	Central stoneroller Striped shiner	Creek chub Common shiner
Group 4	Midventral stripe	Golden shiner Emerald shiner Mimic shiner	Rosyface shiner Silverband shiner Fathead minnow
Group 5	Scattered breast	Bigmouth shiner	
Group 6	Outlined gut	River shiner Spotfin shiner	Red shiner

9.1.4 Data Analysis

Collections made during entrainment sampling at the LEC were summarized for each study year based on the relative composition of total catches as well as temporal patterns of abundance observed across the study period. Diel patterns of entrainment were analyzed based on densities observed during 6-hour sampling intervals. Length distributions were determined for taxa and life stages collected in adequate numbers during each study year.

The study periods encompassed months when entrainment of fish larvae was expected to occur. As supported by low collections made during March and September, it was assumed that no entrainment occurred outside of the study period (January – February and October – December) when estimating total annual entrainment during each study year. Entrainment densities (scaled to 1,000 m^3) were estimated for each 6-hour sampling interval by dividing the number of organisms collected by taxon and life stage by the volume of cooling water sampled during the 6-hour sampling interval. Linear interpolation was applied to entrainment densities observed during consecutive sampling events for each 6-hour sampling interval to estimate densities during the same 6-hour intervals on days when entrainment sampling did not occur. Thus, estimates of annual entrainment for each species and life stage were calculated by summing estimated totals derived by multiplying density estimates by the total volume of cooling water measured at the LEC CWIS during each 6-hour time interval as follows:

$$Annual\ Entrainment = \sum_{i=1}^{365}\sum_{j=1}^{4}\left(D_{ij} \times V_{ij}\right)$$

where:

D_{ij} = Density of species entrained during interval (j) of day (i);

[1] The shoal chub was elevated to full species status from the speckled chub species-complex through morphological studies by Eisenhour (1999, 2004) and genetic studies by Underwood et al. (2003). Henceforth, all specimens formerly identified as speckled chub are now identified as shoal chub.

V_{ij} = Total cooling water flow at the unit during interval (j) of day (i).

9.1.5 Quality Assurance

A Quality Assurance Project Plan (QAPP) was prepared and consistently enforced to ensure that the data generated by the entrainment characterization studies met an acceptable standard of quality with a stated level of confidence. Quality assurance (QA) consisted of an integrated system involving quality planning, quality control (QC), quality assessment, quality reporting, and quality improvement. The QAPP incorporated QA/QC activities of both the field contractor (Wood) and the analysis/reporting contractor (ASA), starting with study design and continuing through project management, oversight of data generation and acquisition, data validation and usability, data management and analysis, report preparation, and record keeping.

Standard operating procedures (SOPs) were prepared and adhered to for all data collecting activities. To ensure site-specific applicability and compliance by project personnel, field and laboratory SOPs were prepared by the field contractor, and then carefully reviewed by the analysis/reporting contractor to confirm that all necessary study elements were addressed thoroughly and adequately to ensure data quality. The SOPs are control documents and include QC procedures to ensure that specified quality standards and objectives are met, including precision, accuracy, completeness, representativeness, and comparability. The SOPs cover all aspects of sampling, including equipment description; calibration procedures; pre-sampling and sampling procedures; sample processing and analysis (taxonomic identification, length measurements, subsampling etc.); sample identification, handling and custody; and data recording and database entry.

Project staff were highly qualified for their tasks and trained specifically for adherence to the SOPs and any additional aspects of the program, such as equipment operation, site security, and safety procedures. In addition, periodic auditing of each data collection activity in the field and laboratory were conducted by senior personnel from the two cooperating contractors to ensure that the protocols and procedures were being followed correctly and that resultant findings are reliable. The audits addressed a predetermined set of criteria that cover the critical aspects of sampling, and the audit results were transmitted to project supervisory staff to administer corrective action if necessary. All procedures and results were documented.

QC consisted of systematic procedures designed to monitor and ensure the quality of the data. QC procedures would lead to response actions if needed to bring the data within control limits, through actions such as exclusion or reanalysis of faulty data, retraining of personnel, and repair or recalibration of equipment. Examples of QC procedures include the following:

- Sampling equipment—preventive maintenance, calibration following manufacturers specifications to ensure functioning within tolerances, parts replacement as needed

- Taxonomic identification—training in taxonomy, auditing of identifications, preservation of samples for future confirmation, use of voucher specimens for all captured taxa, and third party verification by expert taxonomists

- Sample processing—SOP-specified percentage of samples to repeat processing for counts, identification, and length measurement

All laboratory processing was subjected to a statistically based QC process for a continuous sampling plan (CSP, derived from military-standard MIL-STD 1235B), which guarantees an Average Outgoing Quality Limit (AOQL) of 5 percent, i.e., no more than 5 percent of samples could fail to meet acceptance criteria. The acceptance criterion for sample sorting is that at least

95 percent of the ichthyoplankton (fish eggs and larvae) have been detected in the sample. Identification acceptance criterion is that at least 95 percent of the organisms have been correctly identified to lowest taxon and life stage. Samples not achieving these acceptance criteria would be rejected and reprocessed according to prescribed CSP procedures.

Data verification and validation of field data were conducted during the course of the project to ensure that the resulting data were suitable for their intended use. Project records, including field sampling logs, raw data sheets, sample chain-of-custody forms and instrument calibration logs were reviewed to verify that data were collected according to the QAPP. Data were validated first by a review of datasheets and data files to determine if data were incomplete or appeared to be inappropriate or out of a reasonable range of values.

The field data were initially entered into a project developed Access database, then reviewed by a second individual for accuracy and completeness. Data entry into the database underwent a 100 percent visual QC comparison to the data on the corresponding data sheets. Data files were subjected to error checking programs to detect outlying values, either to investigate further or to eliminate if shown to be spurious. This investigation would require tracing the data to raw data sheets and consulting with field or laboratory personnel who recorded the data. All raw data sheets, log books, and data files are maintained for future reference. All computer files were backed up on a daily basis while any data entry or editing procedures were ongoing. Data reports generated from the database were checked at a 20 percent frequency to ensure that the programs were performing correctly.

9.2 LEC ENTRAINMENT

9.2.1 Physical Conditions

9.2.1.1 River Conditions

The USGS gage 06935550 at the LEC provided continuous measurements of river conditions across both study years after its installation in April 2015. Water temperature, gage height, and discharge measurements made at the LEC gage (Figure 9-2) corresponded closely to those made at the Hermann gage (Figure 9-3), which provided a historical context for measurements observed during the study years. Water quality measurements (Figure 9-4) collected with each entrainment sample provided further information about the conditions in the Missouri River at the LEC across the study periods.

Mean daily water temperatures recorded at the Hermann gage during the period from March through September in 2015 ranged from 32.7 to 83.8 °F with a median value of 73.9 °F, whereas during the same period in 2016, temperatures ranged from 44.1 to 86.5 °F with a median value of 74.7 °F (Figure 9-3). The median daily temperature measured during this time of year was 73.0 °F based on data collected since 2006. Similar temperatures were measured at the LEC gage (Figure 9-2) and CWIS during entrainment sampling (Figure 9-4).

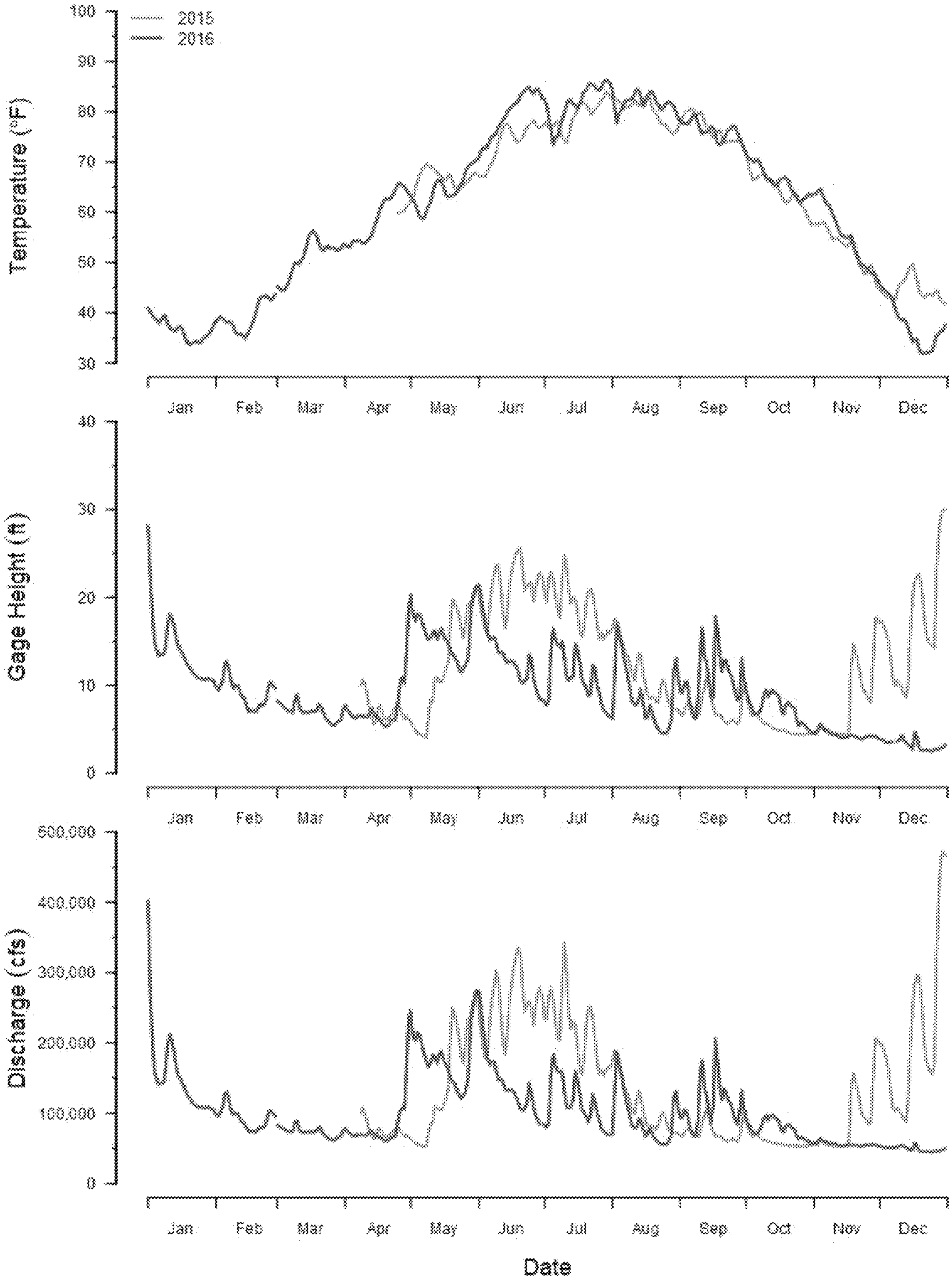
With the exception of a brief warm period in late April and early May, water temperatures measured throughout the 2015 study year tended to near or below median seasonal values recorded at the Hermann gage (Figure 9-3). In fact, temperatures in early March 2015 were among the coldest recorded during that time of year. By contrast, cool periods in late April and May 2016 preceded a continuous period of warming that resulted in temperatures approaching or exceeding the warmest measurements made during June at the facility (Figure 9-3). Temperatures were similar to median values during the remainder of the 2016 study year with the exception of two periods of rapid cooling that occurred in early and late July.

Gage heights and discharges measured at the LEC indicated that river flows followed a consistent seasonal trend with maximum peaks observed outside of the study periods in the late fall and early winter months and periods of elevated discharge occurring from spring through mid-summer during the study periods (Figure 9-2). Summer discharges during 2015 approached values in the 95th percentile for that time of year, whereas 2016 flows were similar to median values throughout the study period with the exception of springtime peaks that also approached values in the 95th percentile (Figure 9-3). Thus, the entrainment characterization study years were representative of the variability in flow conditions in the LMOR with one high-flow year (2015) followed by a year with typical flows (2016).

DO concentrations tended to decrease throughout each study year as water temperatures increased and sampling event means ranged from 4.2 to 17.0 mg/L in 2015 and 3.3 to 11.4 mg/L in 2016 (Figure 9-4). DO in 2015 was notably higher during early March and from August through September relative to 2016 means measured during the same time of year. No seasonal trend was apparent for specific conductivity as mean values ranged from 345.9 to 799.6 µS/cm across both study years (Figure 9-4).

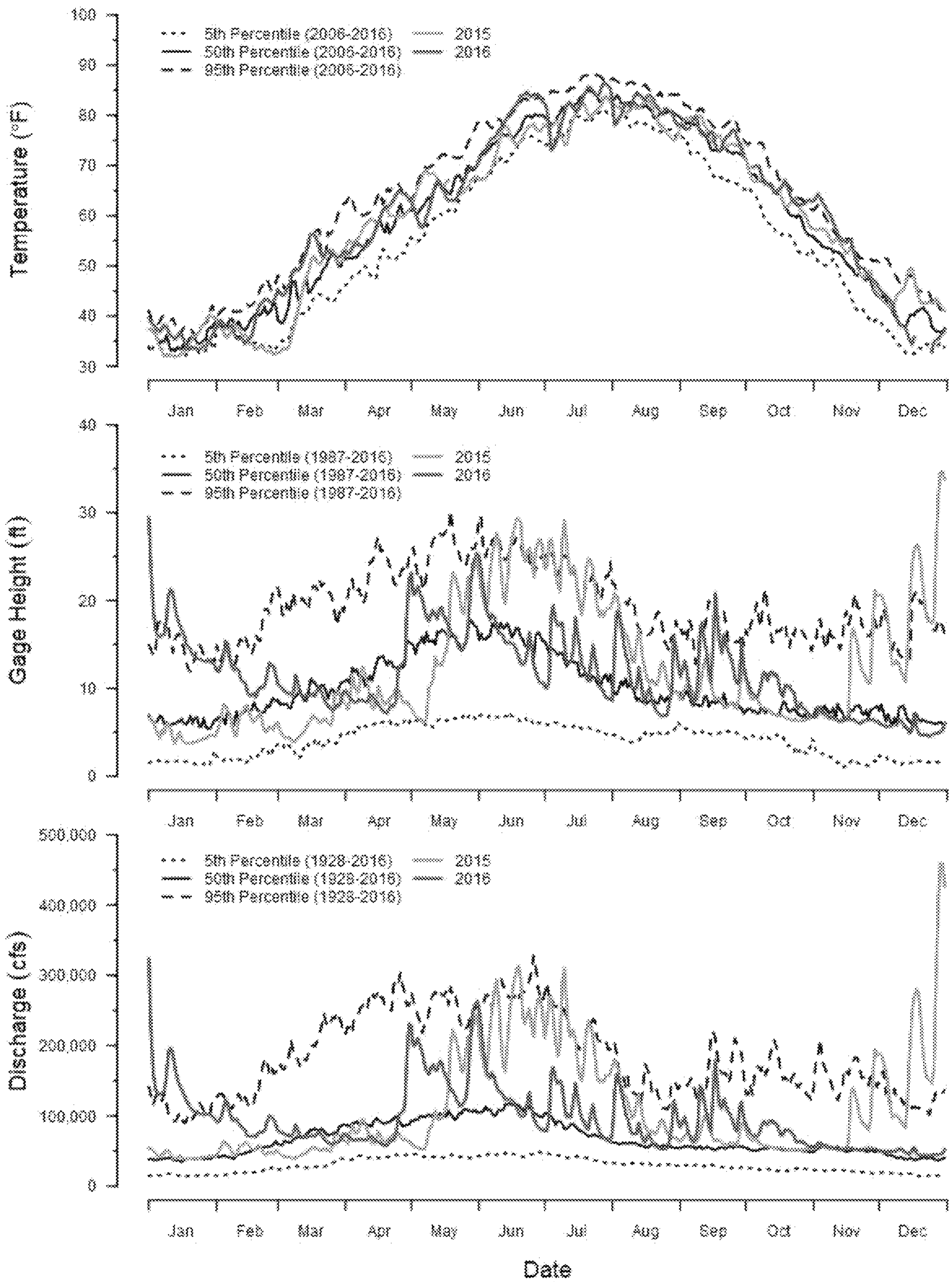
9.2.1.2 Facility Operations

Mean daily cooling water flows (Figure 9-5) measured at the LEC intake from March through September during 2015 and 2016 were 1,384 MGD and 1,232 MGD, respectively. Withdrawal rates in May, June, and July during 2015 were 21, 14, and 10 percent greater, respectively, than during the same months in 2016. These months correspond to the time period when a majority of ichthyoplankton entrainment was expected to occur. Reduced flows during specific months (e.g., April of both years) may represent unit outages scheduled for routine maintenance.



Source: USGS 2018.

Figure 9-2 Mean Daily Water Temperature, Gage Height, and Discharge Measured at the LEC Gage from April 2015 Through 2016.



Source: USGS 2018.

Figure 9-3 Mean Daily Water Temperature, Gage Height, and Discharge Measured at the Hermann Gage During 2015 and 2016 and Historical Percentile Values.

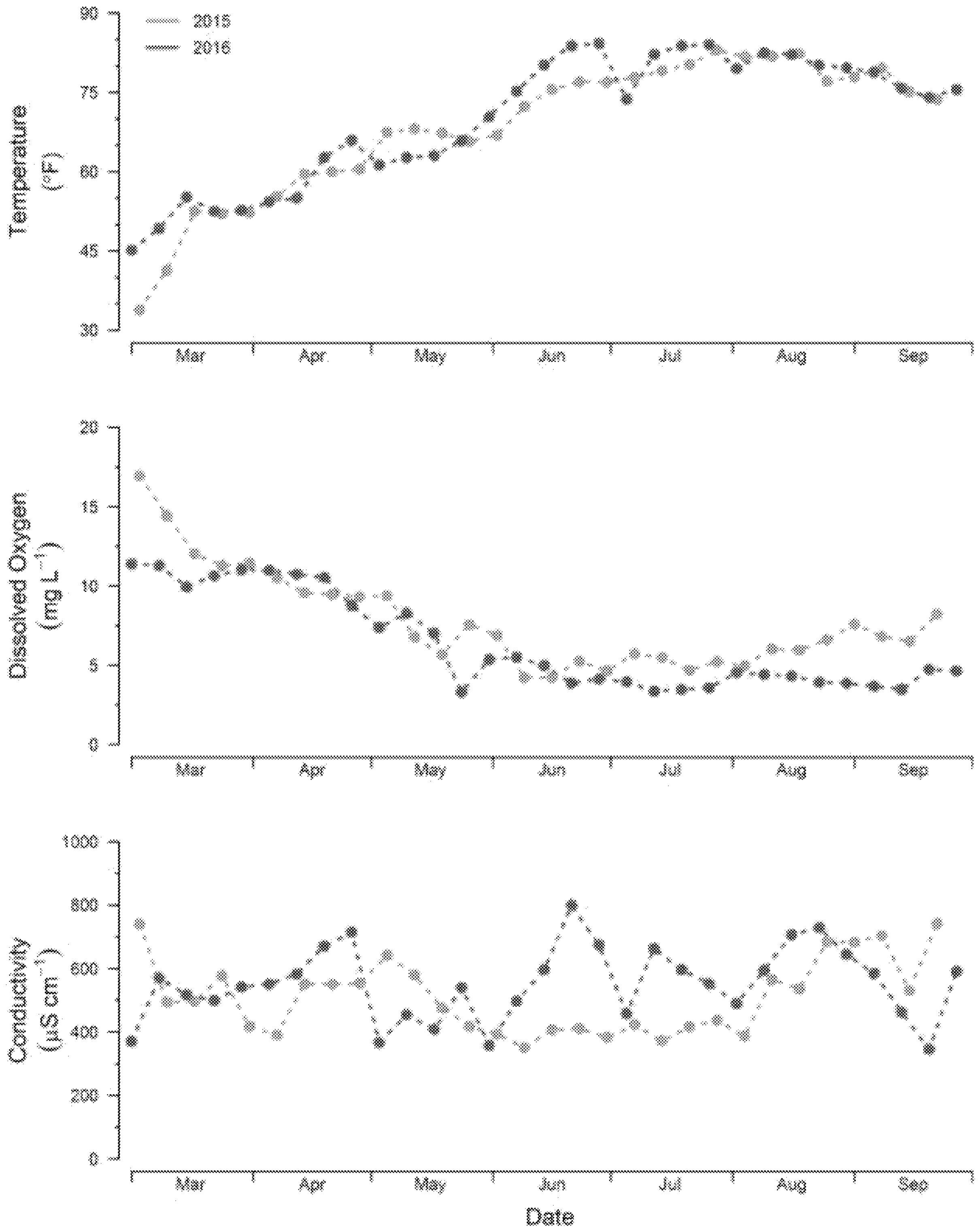
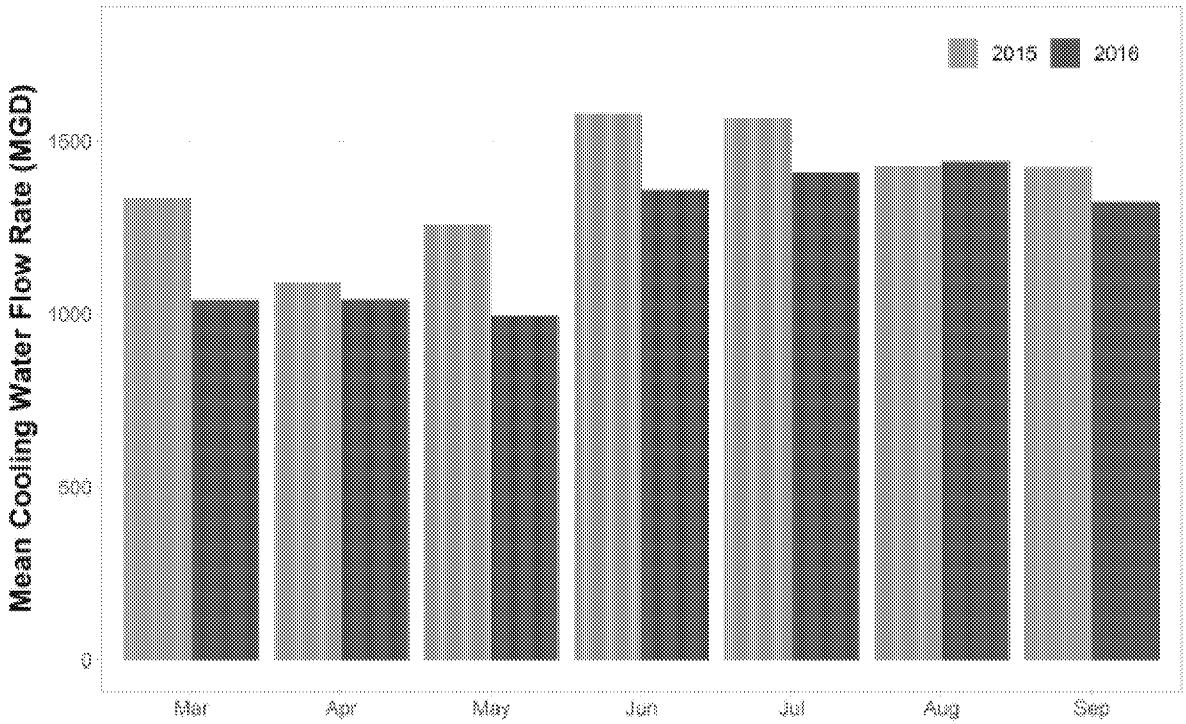


Figure 9-4 Mean Water Temperature, DO, and Specific Conductivity Measured at the LEC CWIS During Entrainment Sampling Events Across the 2015 and 2016 Study Years.



Source: Ameren LEC.

Figure 9-5 Mean Daily Cooling Water Flows by Month Measured at the LEC Intake During 2015 and 2016.

9.2.2 Species Composition

A total of 70,704 fish eggs, larvae, juveniles, and adults representing 10 families and 14 identifiable species was collected during 2015 entrainment sampling conducted at the LEC discharge (Table 9-3). Asian carps in the genus *Hypophthalmichthys*, such as silver carp (*Hypophthalmichthys molitrix*) and bighead carp (*Hypophthalmichthys nobilis*), and grass carp (*Ctenopharyngodon idella*) accounted for approximately 84 percent of all collected specimens. Fishes that could not be identified to any taxonomic level were also numerous in 2015, representing approximately 9 percent of the total catch. Carps and minnows in the Cyprinidae family unidentifiable to species, gizzard shad (*Dorosoma cepedianum*) as well as shads (*Dorosoma* sp.) unidentifiable to species, freshwater drum (*Aplodinotus grunniens*), carpsuckers (*Carpiodes* sp.) and buffalos (*Ictiobus* sp.) in the subfamily Ictiobinae unidentifiable to species, goldeye (*Hiodon alosoides*), and common carp (*Cyprinus carpio*) accounted for the majority of all remaining specimens.

Larvae of indistinguishable stages of development (LAR) and PYSL represented approximately 48 and 47 percent of all specimens collected during 2015 sampling, respectively. YSL larvae accounted for nearly 5 percent of specimens, whereas eggs, juveniles, and adults collectively comprised less than 1 percent of the total collection. The majority of all larval stages were represented by Asian carp from the genus *Hypophthalmichthys*. Freshwater drum, the only taxon with identifiable eggs during 2015 sampling, accounted for 37 percent of all fish eggs. Gizzard shad comprised 48 percent of all juveniles. A single shoal chub (*Macrhybopsis hyostoma*) was the only adult fish collected during 2015.

A total of 49,986 fish eggs, larvae, juveniles, and adults representing 11 families and 15 identifiable species was collected during 2016 entrainment sampling (Table 9-3). Asian carps again dominated the total collection, representing approximately 85 percent of all specimens. Carps and minnows in the Cyprinidae family unidentifiable to species, freshwater drum, unidentifed fishes, carpsuckers and buffalos in the subfamily Ictiobinae unidentifiable to species, gizzard shad, mooneyes (*Hiodon* sp.), and common carp collectively accounted for another 14 percent of collected specimens.

YSL accounted for approximately 64 percent of all specimens collected during 2016. Larvae of indistinguishable stages of development represented 32 percent of specimens, whereas PYSL and eggs each comprised approximately 2 percent of the total collection. The majority of YSL and indistinguishable larvae were represented by Asian carp from the genus *Hypophthalmichthys*. Freshwater drum, Asian carps, carpsuckers and buffalos in the subfamily Ictiobinae unidentifiable to species, and gizzard shad were all numerous among PYSL specimens. Only 5 percent of eggs were identified as freshwater drum. A small number (6 eggs) were identified as belonging to Asian carp from the genus *Hypophthalmichthys*. Gizzard shad represented 45 percent of juveniles and a single western mosquitofish (*Gambusia affinis*) was the only adult collected during 2016.

No federal or state threatened or endangered species were identified during either study year.

Table 9-3 Taxonomic and Development Stage Composition of Fish Collected During 2015 and 2016 Entrainment Characterization Sampling at the LEC.

2015 Study Year								
Taxon	Eggs	YSL	PYSL	LAR	Juveniles	Adults	Total	Percent
Silver and bighead	--	2,782	30,202	26,408	9	0	59,401	84.0
Unidentified fishes	192	0	1,115	5,181	2	0	6,490	9.2
Minnow family	--	8	185	1,621	0	0	1,814	2.6
Gizzard shad	--	0	715	304	50	0	1,069	1.5
Freshwater drum	114	0	313	147	2	0	576	0.8
Carpsuckers	--	107	125	55	0	0	287	0.4
Goldeye	--	97	148	0	4	0	249	0.4
Grass carp	--	120	49	0	0	0	169	0.2
Shads	--	0	41	128	0	0	169	0.2
Common carp	--	2	84	12	20	0	118	0.2
Buffalos	--	41	22	8	2	0	73	0.1
Carpsuckers	--	35	23	0	0	0	58	0.1
Minnows group 2	--	0	38	0	0	0	38	0.1
Sucker family	--	0	1	35	0	0	36	0.1
Walleye	--	0	32	1	0	0	33	0.1
Redhorse suckers	--	10	14	4	0	0	28	<0.1
Mooneyes (*Hiodon)*	--	0	16	8	0	0	24	<0.1
White sucker	--	2	15	3	0	0	20	<0.1
Sunfish family	--	0	13	0	1	0	14	<0.1
Crappies	--	0	0	0	8	0	8	<0.1
Channel catfish	--	0	2	1	3	0	6	<0.1
Silver carp	--	0	4	0	1	0	5	<0.1
Shortnose gar	--	0	0	4	0	0	4	<0.1
Walleye and sauger	--	0	4	0	0	0	4	<0.1
White bass	--	0	2	0	2	0	4	<0.1
White crappie	--	0	2	0	0	0	2	<0.1
Blue catfish	--	0	1	0	0	0	1	<0.1
North American catfish	--	0	1	0	0	0	1	<0.1
Minnows group 5	--	0	1	0	0	0	1	<0.1
Minnows group 6	--	0	1	0	0	0	1	<0.1
Shoal chub	--	0	0	0	0	1	1	<0.1
Study Year	**306**	**3,204**	**33,169**	**33,920**	**104**	**1**	**70,704**	**100.0**
2016 Study Year								
Taxon	Eggs	YSL	PYSL	LAR	Juveniles	Adults	Total	Percent
Silver and bighead	6	28,143	276	11,505	0	0	39,930	79.9
Minnow family	--	1	2	3,645	0	0	3,648	7.3
Grass carp	--	2,434	113	75	0	0	2,622	5.3
Freshwater drum	38	609	282	91	1	0	1,021	2.0
Unidentified fishes	711	14	1	190	1	0	917	1.8
Carpsuckers and	--	150	179	385	0	0	714	1.4
Carpsuckers	--	184	51	17	0	0	252	0.5
Gizzard shad	--	0	107	40	10	0	157	0.3
Mooneyes (*Hiodon*)	--	13	16	128	0	0	157	0.3
Buffalos	--	102	34	0	0	0	136	0.3
Common carp	--	33	56	8	4	0	101	0.2
Goldeye	--	93	1	1	0	0	95	0.2

2015 Study Year								
Taxon	Eggs	YSL	PYSL	LAR	Juveniles	Adults	Total	Percent
Minnows group 2	--	20	12	8	0	0	40	0.1
White bass	--	32	0	0	0	0	32	0.1
Mooneye	--	26	1	2	0	0	29	0.1
Blue sucker	--	12	5	8	0	0	25	0.1
Sunfishes (*Lepomis)*	--	2	14	0	2	0	18	<0.1
Sucker family	--	0	0	16	0	0	16	<0.1
White sucker	--	0	2	12	0	0	14	<0.1
Shads	--	0	0	10	0	0	10	<0.1
Blue catfish	--	1	3	3	2	0	9	<0.1
Redhorse suckers	--	1	5	0	0	0	6	<0.1
Walleye and sauger	--	2	4	0	0	0	6	<0.1
Minnows group 6	--	0	3	2	0	0	5	<0.1
Darters (*Etheostoma)*	--	1	2	0	0	0	3	<0.1
Logperch	--	1	1	1	0	0	3	<0.1
Minnows group 3	--	0	3	0	0	0	3	<0.1
Minnows group 4	--	1	2	0	0	0	3	<0.1
Sunfish family	--	0	3	0	0	0	3	<0.1
Catfishes (*Ictalurus*	--	0	0	0	2	0	2	<0.1
Crappies	--	0	2	0	0	0	2	<0.1
Darters (*Percina*)	--	1	0	0	0	0	1	<0.1
Paddlefish	--	0	0	1	0	0	1	<0.1
Redhorses and white	--	0	1	0	0	0	1	<0.1
Western mosquitofish	--	0	0	0	0	1	1	<0.1
Walleye	--	0	1	0	0	0	1	<0.1
Channel catfish	--	0	0	0	1	0	1	<0.1
North American catfish	--	1	0	0	0	0	1	<0.1
Study Year	**755**	**31,877**	**1,182**	**16,148**	**23**	**1**	**49,986**	**100.0**
Grand Total	**1,061**	**35,081**	**34,351**	**50,068**	**127**	**2**	**120,69**	--
No. of	**2**	**8**	**9**	**9**	**8**	**2**	**12**	--
No. of	**2**	**10**	**15**	**14**	**16**	**2**	**19**	--

9.2.3 Seasonal Patterns

9.2.3.1 All Taxa and Life Stages

Entrainment was observed in samples collected from late March through late-September during 2015 (Figure 9-6), with most entrainment taking place from mid-May to mid-June when 91 percent of all specimens were collected. Density of eggs peaked in early June and remained elevated through mid-June. Densities of PYSL and YSL peaked in mid-May and late-May, respectively, before gradually decreasing throughout June to low levels for both development stages. A similar trend was observed for densities of larvae of indistinguishable stages of development, which accounted for a large proportion of all fish larvae collected and may have confounded comparisons of temporal trends of abundance of YSL and PYSL if either group was disproportionately represented as indistinguishable larvae. Fish juveniles were present in collections made between mid-June and mid-August with densities greatest from mid-June through mid-July. A single adult shoal chub was collected in early April.

Entrainment was observed in samples collected from late March through late-September during 2016 (Figure 9-6), with most entrainment taking place from mid-May to early June when 86 percent of all specimens were collected. Densities of fish eggs and YSL were greatest from mid-

May to late-May, whereas PYSL densities were elevated from late-May through mid-June. Larvae of indistinguishable stages of development, which declined in abundance by 52 percent relative to 2015, were most numerous from mid-May to late May. Fish juveniles were present in collections made between early June and late-August with densities greatest in late July and early August. A single adult western mosquitofish was collected in early August.

Seasonal patterns of entrainment of major taxa groups collected during sampling are presented below. Seasonal patterns of entrainment for each taxon and life stage are presented in Table A-2 in Appendix 9 A and in figures found in Appendix 9 B.

9.2.3.2 Asian Carps

Density of Asian carps in the genus *Hypophthalmichthys* (silver carp and bighead carp) were greatest from early May through early June during 2015 sampling (Figure 9-7). Most specimens were either PYSL or larvae of indistinguishable development stage. Juveniles were collected from mid-June through July.

Nearly all silver carp and bighead carp were collected from mid-May through early June during 2016 sampling (Figure 9-7). A small number of eggs were collected during early August and no juveniles were present during 2016 sampling. The vast majority of specimens were YSL, which contrasted with 2015 sampling, when PYSL were the dominant development stage collected. These differences in life stage composition may have reflected river conditions during each study year as well as an improved ability to differentiate between life stages following a full year of sampling and the addition of the river ichthyoplankton sampling program. Despite a large reduction in the number of larvae of indistinguishable development stage collected during 2016 in comparison to 2015, the seasonal pattern and magnitude of peak densities for this life stage category were relatively similar between study years.

Grass carp larvae primarily were collected during late May/early June and from August to mid-September during both years of sampling (Figure 9-8). Densities of all larval stages were notably higher during 2016 in comparison to 2015. The majority of specimens were YSL. No juvenile grass carp were collected during either year of sampling.

9.2.3.3 Common Carp

Common carp, which were present at lower densities than Asian carp, were collected from mid-May through mid-July during 2015 entrainment sampling (Figure 9-9). The majority of specimens were PYSL collected in May and early June. Juveniles were collected from mid-June through early July.

Common carp densities during 2016 sampling (Figure 9-9) were relatively similar to those observed during 2015. Nearly all specimens were collected in May and early June. Density of YSL larvae was elevated in mid-May, whereas density of PYSL peaked in late May. Four juveniles were collected in early June.

9.2.3.4 Other Minnows

After excluding Asian carps and common carp, most remaining minnows in the Cyprinidae family were collected as larvae of indistinguishable development stage between mid-May and mid-June during 2015 entrainment sampling (Figure 9-10). Most PYSL were collected during early June. One adult shoal chub was collected in early April. No juveniles were collected during 2015.

Densities of carps and minnows (excluding Asian carps and common carp) during 2016 entrainment sampling (Figure 9-10) generally were greater than those observed in 2015. Most were collected as larvae of indistinguishable development stage during mid-May, whereas densities of YSL and PYSL peaked in early June and early August, respectively. No juvenile or adults were collected during 2016.

9.2.3.5 Carpsuckers and Buffalos

Nearly all YSL of carpsuckers and buffalos in the subfamily Ictiobinae collected during 2015 entrainment sampling (Figure 9-11) were caught during a single sampling event in late May, whereas PYSL were primarily collected during May and early June with periodic collections made throughout July and August. Larvae of indistinguishable development stage were primarily collected in late April and early May. Two juvenile buffalos were collected during late June.

Densities of carpsuckers and buffalos during 2016 entrainment sampling (Figure 9-11) generally were greater than those observed in 2015. YSL were collected between late April and mid-August with periods of elevated density occurring in early to mid-May, early June, and mid-July. PYSL density peaked during late April with additional periods of elevated density occurring in mid-June and early July. The majority of larvae of indistinguishable development stage were collected during early May and mid-June. No juvenile carpsuckers or buffalos were collected during 2016.

9.2.3.6 Shads

Larvae of shads, most of which were identified as gizzard shad, were collected between late May and late July during 2015 entrainment sampling (Figure 9-12). The majority were PYSL, which were collected at highest densities in late May and early June. Nearly all larvae of indistinguishable development stage were collected during June. Gizzard shad juveniles were collected from late June through July with peak density occurring in early July. No YSL or adults were observed in 2015 entrainment samples.

Densities of shads during 2016 entrainment sampling (Figure 9-12) were notably lower than those observed in 2015. Specimens were collected between May and early August and most were identified as gizzard shad. As was observed during 2015, PYSL comprised the majority of specimens with elevated densities occurring from late May to mid-June. Most larvae of indistinguishable development stage were collected during May. Gizzard shad juveniles were collected in late July and early August. No YSL or adults were observed in 2016 entrainment samples.

9.2.3.7 Freshwater Drum

Freshwater drum was present in 2015 entrainment samples from mid-May through mid-September (Figure 9-13). Eggs were collected at high densities from early to mid-June and at low densities throughout August and mid-September. Most specimens were PYSL, which were caught at highest densities from June through mid-July. Nearly all larvae of indistinguishable development stage were collected during mid-June. Two juvenile freshwater drum were collected during consecutive sampling events in late June and early July. No YSL or adults were observed in 2015 entrainment samples.

Freshwater drum larval densities during 2016 entrainment sampling (Figure 9-13) generally were greater than those observed in 2015. Entrainment of all specimens occurred between May and late September. The large peak in egg density observed in June during 2015 sampling was not observed in 2016. Instead, periods of elevated egg density occurred in early May and mid-September. YSL, which were absent during 2015 sampling, were the most abundant larvae and most were collected during early and mid-June. The majority of PYSL were caught in mid-June. One juvenile was caught during late July and no adults were collected during 2016.

9.2.3.8 Mooneyes

Mooneyes in the genus *Hiodon*, most of which were identified as goldeye, were collected from May through mid-June during 2015 entrainment sampling (Figure 9-14). Nearly all YSL were collected in late May, whereas PYSL was collected from mid-May to mid-June. Four juvenile goldeye were collected during a single sampling event in mid-June.

Densities of mooneyes during 2016 entrainment sampling (Figure 9-14) were relatively similar to those observed during 2015. Specimens included the species goldeye and mooneye (*Hiodon tergisus*), but the largest contingent of specimens could only be identified to the genus level. YSL were collected throughout May and nearly all PYSL were collected during mid to late-May. A large number of larvae of indistinguishable development stage were collected in late May. No juvenile mooneyes were collected in 2016.

9.2.3.9 Unidentified Fishes

Unidentified fishes were collected from late March through September during 2015 entrainment sampling (Figure 9-15). Their relatively high abundance during the first study year reflected the initial challenges of identifying fragile species known to experience damage during entrainment, such as gizzard shad and bighead carp and silver carp, which were particularly abundant in entrainment samples at the LEC. The vast majority of unidentifiable larvae were noted as damaged and also could not be identified to a stage of development. The abundance patterns of these larvae closely corresponded with those of Asian carps (Figure 9-16), suggesting that these species likely represented a large portion of the unidentified specimens collected during 2015. The implementation of a concurrent river ichthyoplankton sampling program greatly improved the identification of such specimens as the relative abundance of unidentified larvae declined from approximately 9 percent of the 2015 catch to less than 1 percent in 2016.

Unidentified fish eggs were collected from late March through mid-June with peak densities occurring in early and mid-June during 2015 (Figure 9-15). Most unidentified fish larvae that could not be distinguished to a development stage were collected during one sampling event in mid-May, when most unidentified PYSL were collected as well. Two unidentified juvenile fishes were collected during a single sampling event in late June.

Unidentified fishes were collected from mid-April through late September during 2016 entrainment sampling (Figure 9-15). Egg densities were generally greater during 2016 relative to 2015, and most were collected during May and June with peak densities occurring in late May. Nearly all unidentified larvae were indistinguishable to a development stage and no temporal trend of abundance was evident during the 2016 study period. One unidentifiable juvenile was collected in early September.

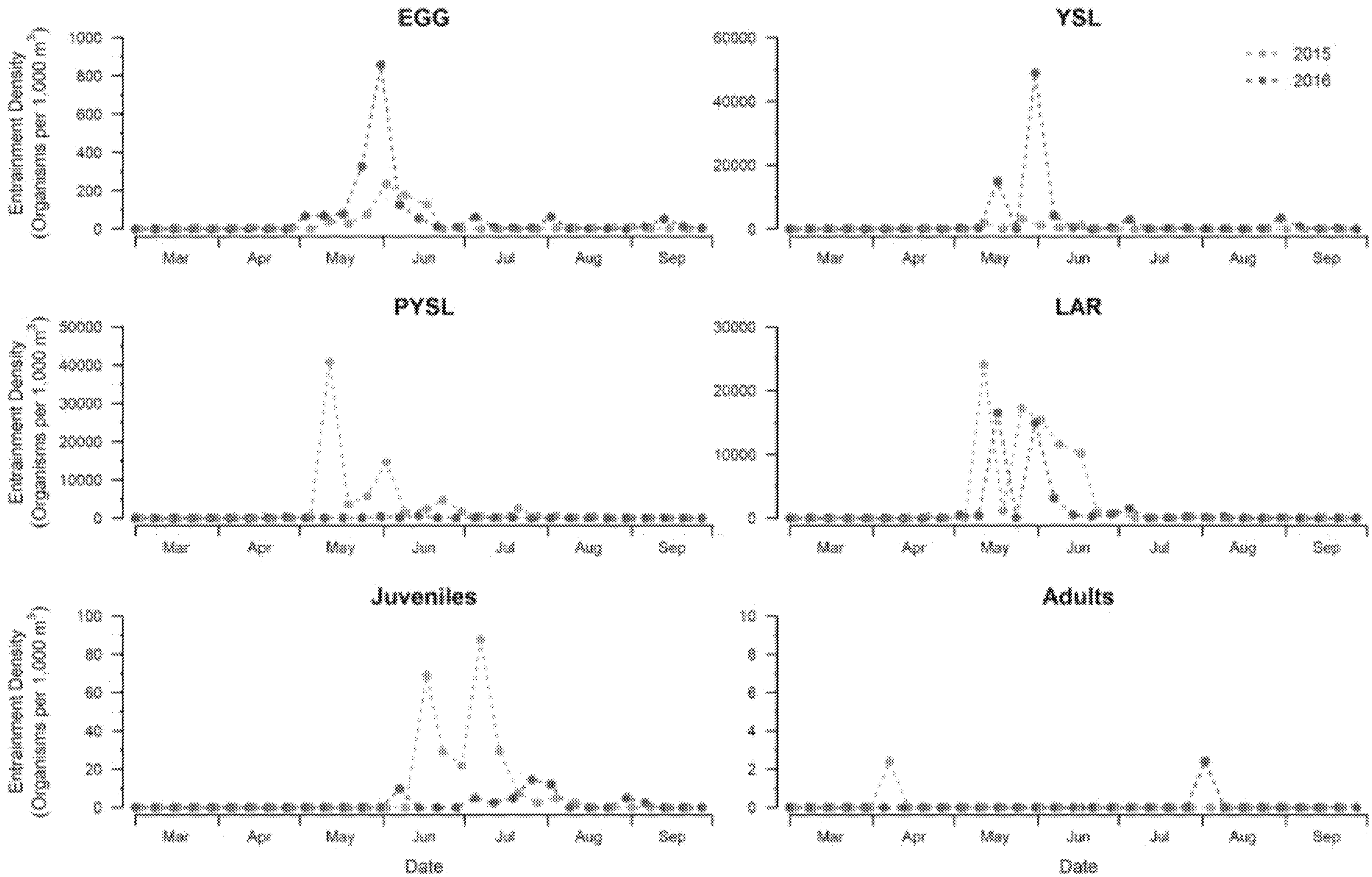


Figure 9-6 Seasonal Pattern of Entrainment of All Taxa and Life Stages During 2015 and 2016 Sampling at the LEC.

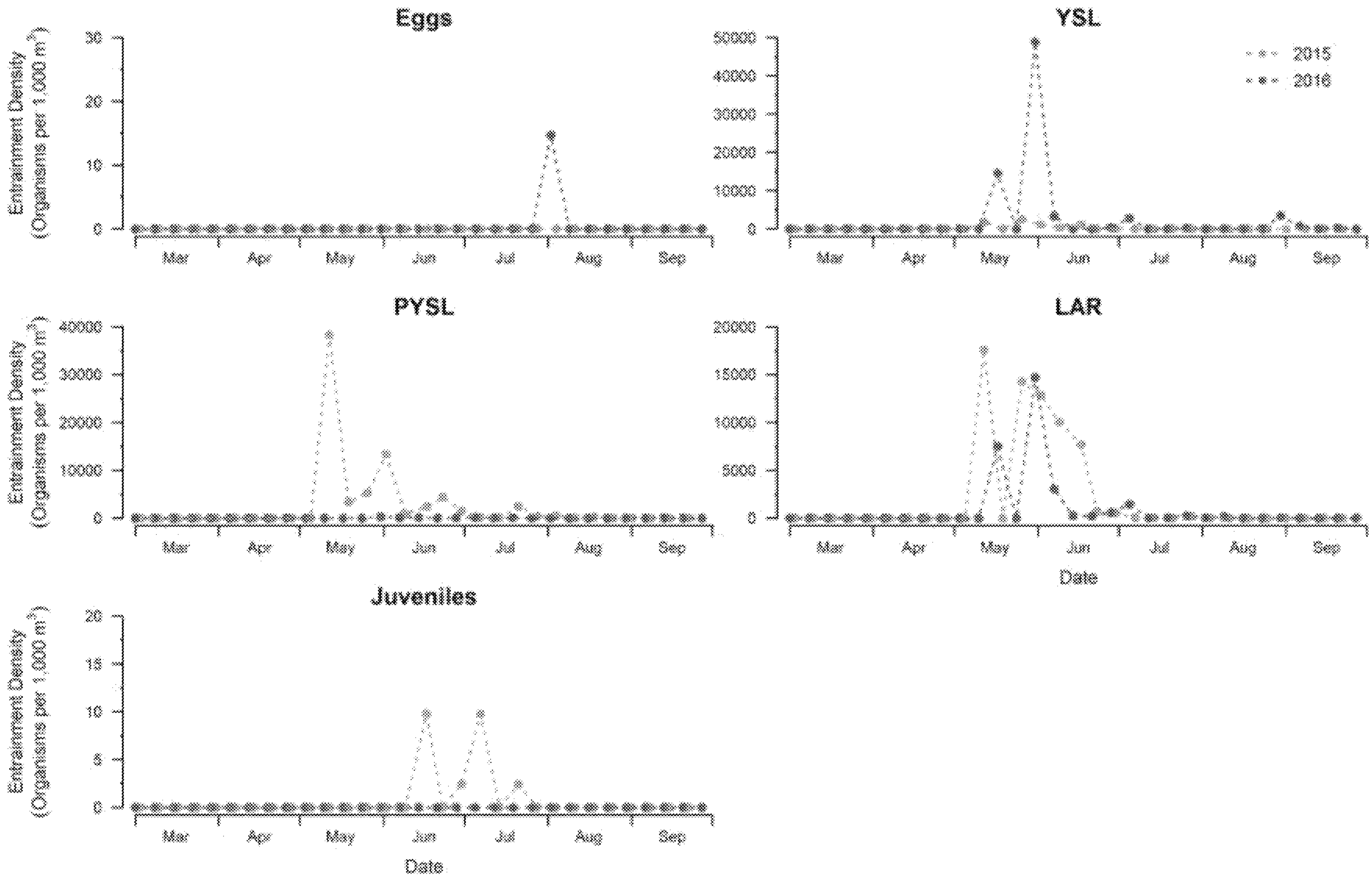


Figure 9-7 Seasonal Pattern of Entrainment of Silver Carp and Bighead Carp During 2015 and 2016 Sampling at the LEC.

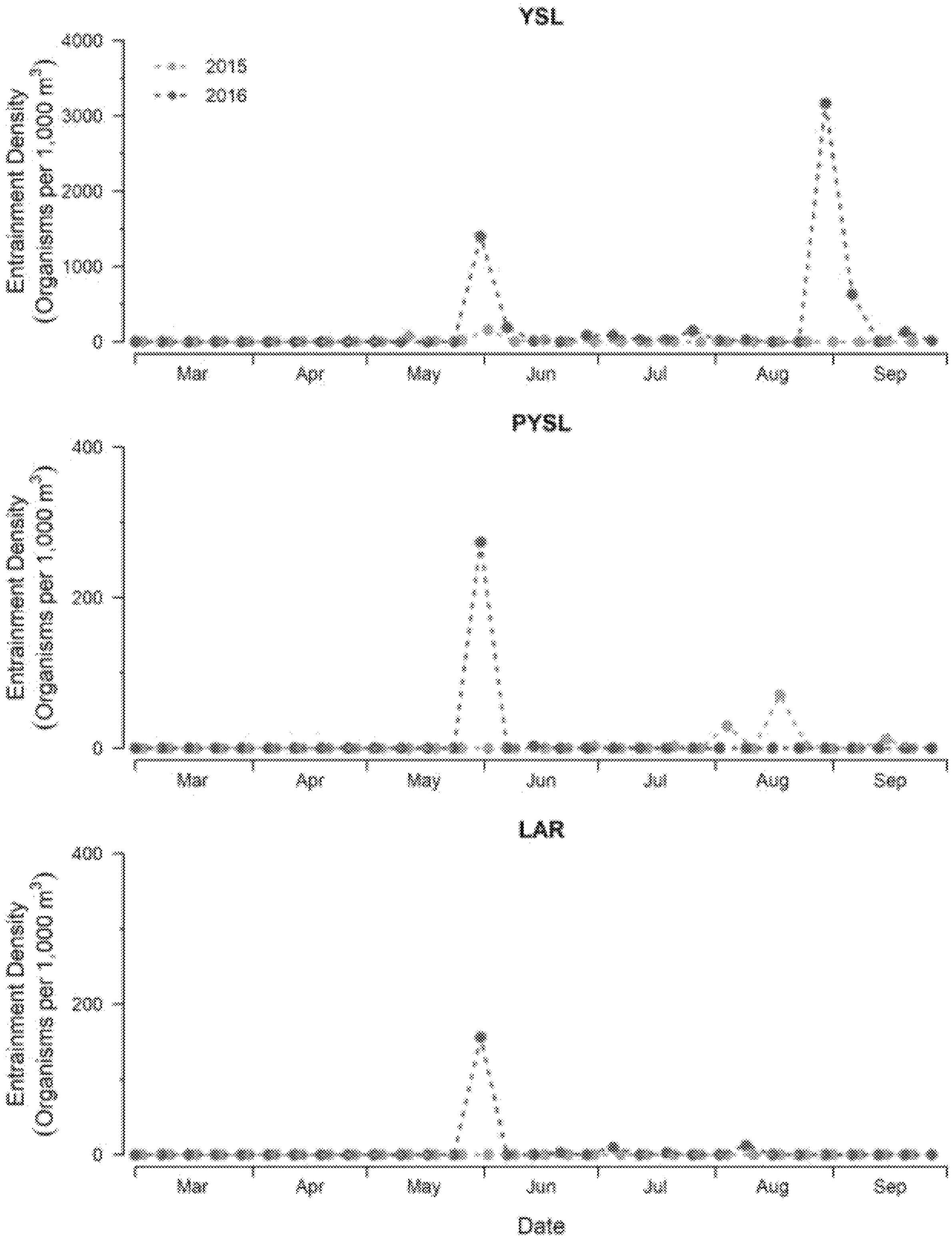


Figure 9-8 Seasonal Pattern of Entrainment of Grass Carp During 2015 and 2016 Sampling at the LEC.

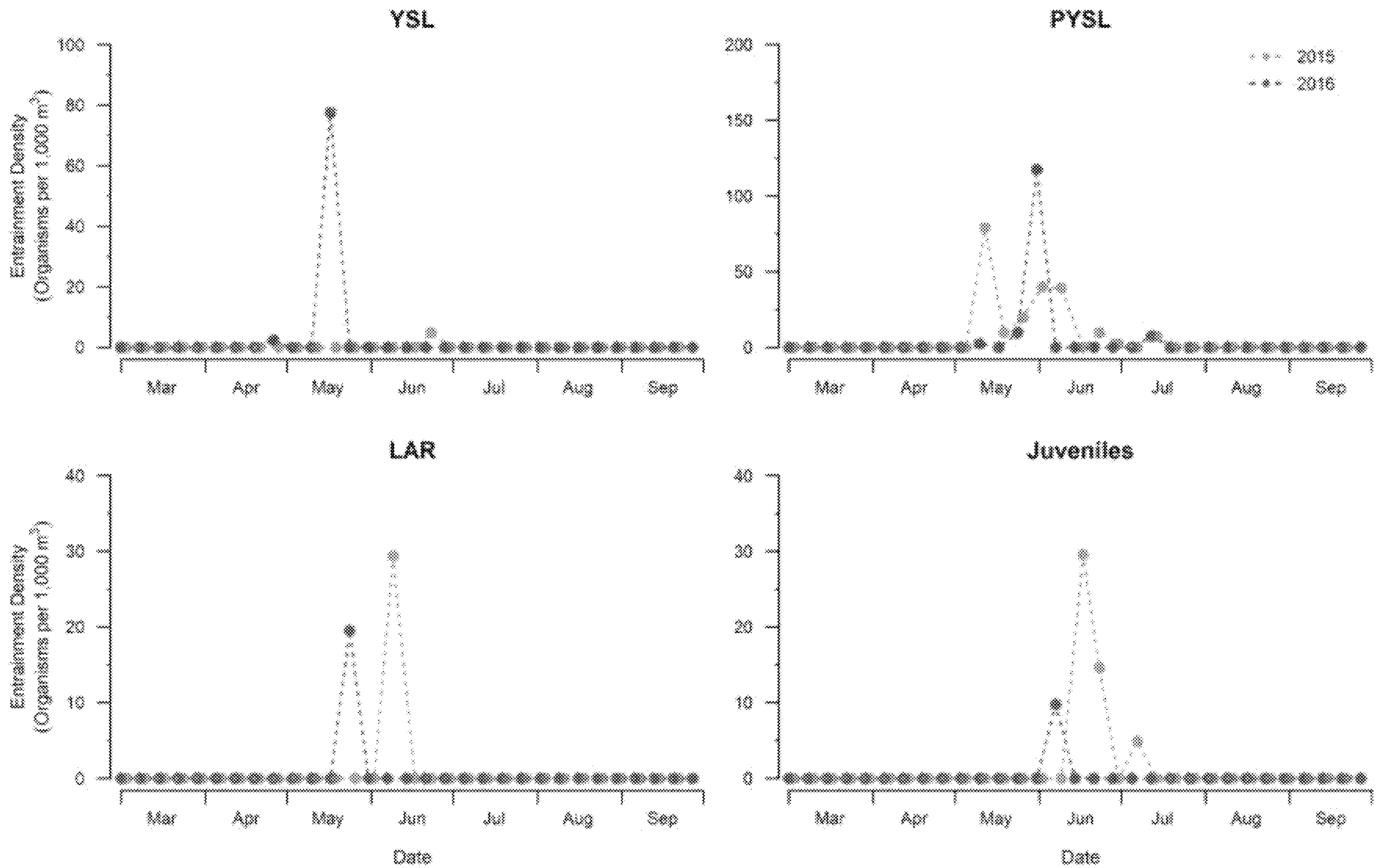


Figure 9-9 Seasonal Pattern of Entrainment of Common Carp During 2015 and 2016 Sampling at the LEC.

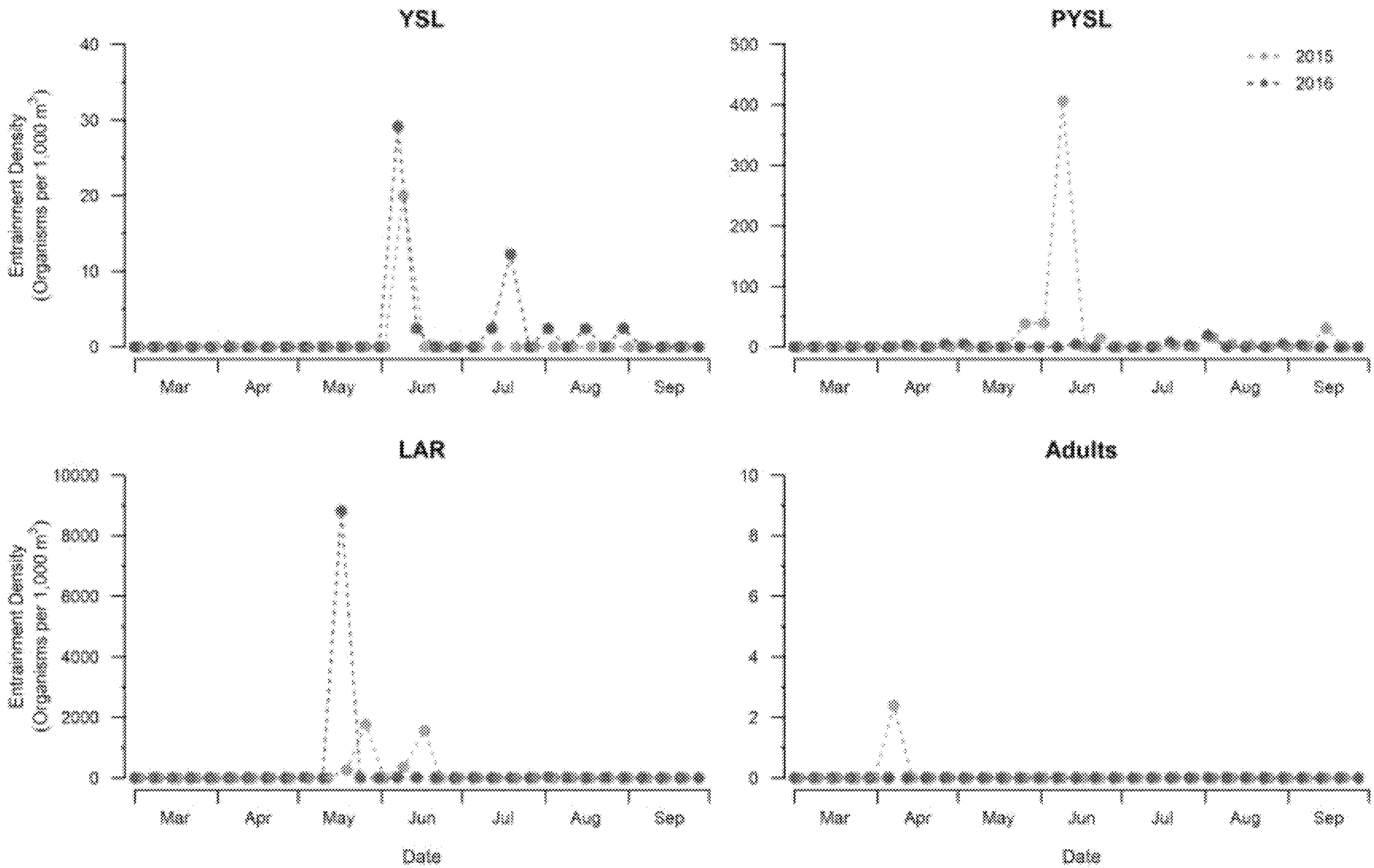


Figure 9-10 Seasonal Pattern of Entrainment of Minnows (Excluding Asian Carps and Common Carp) During 2015 and 2016 Sampling at the LEC.

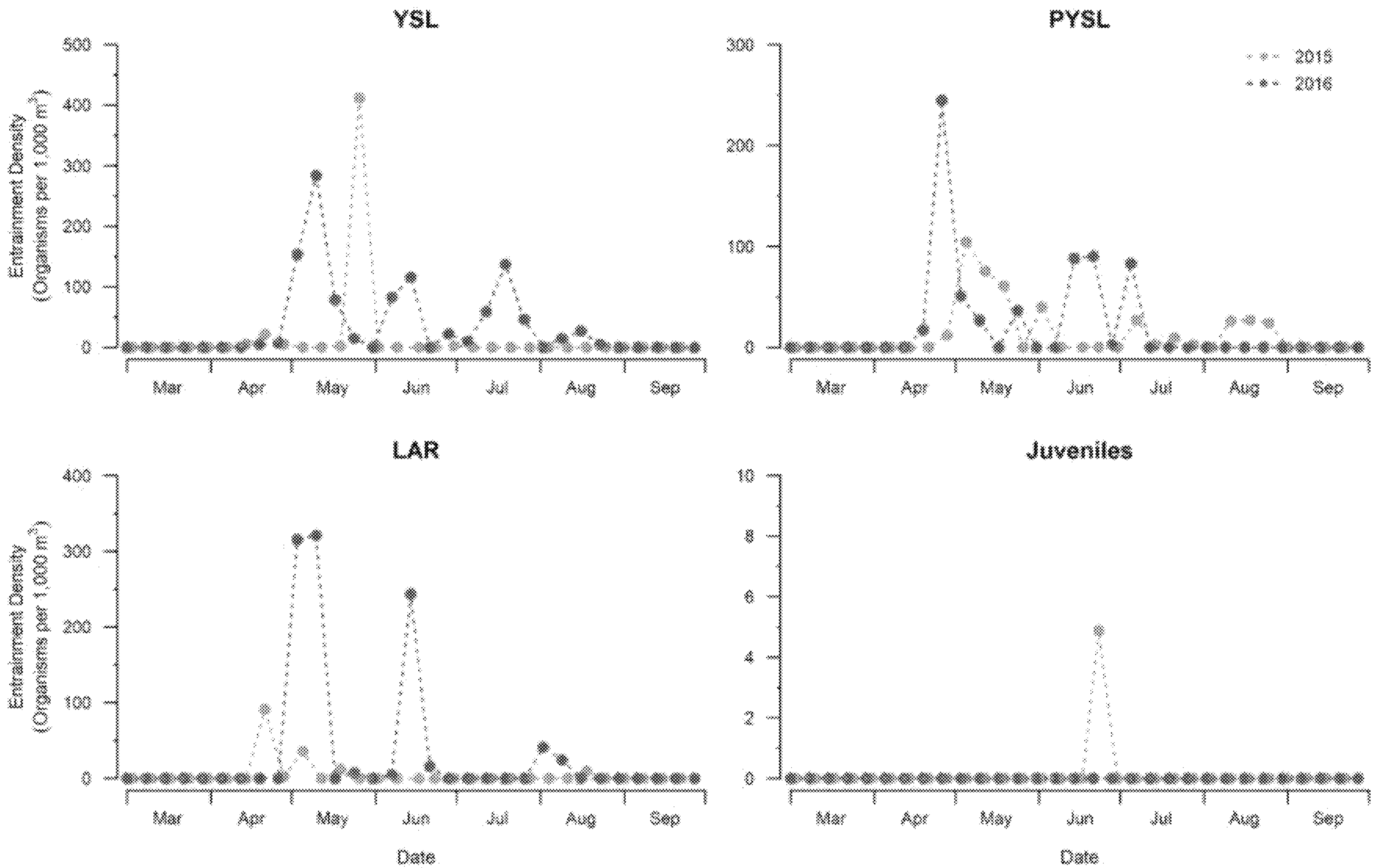


Figure 9-11 Seasonal Pattern of Entrainment of Carpsuckers and Buffalos During 2015 and 2016 Sampling at the LEC.

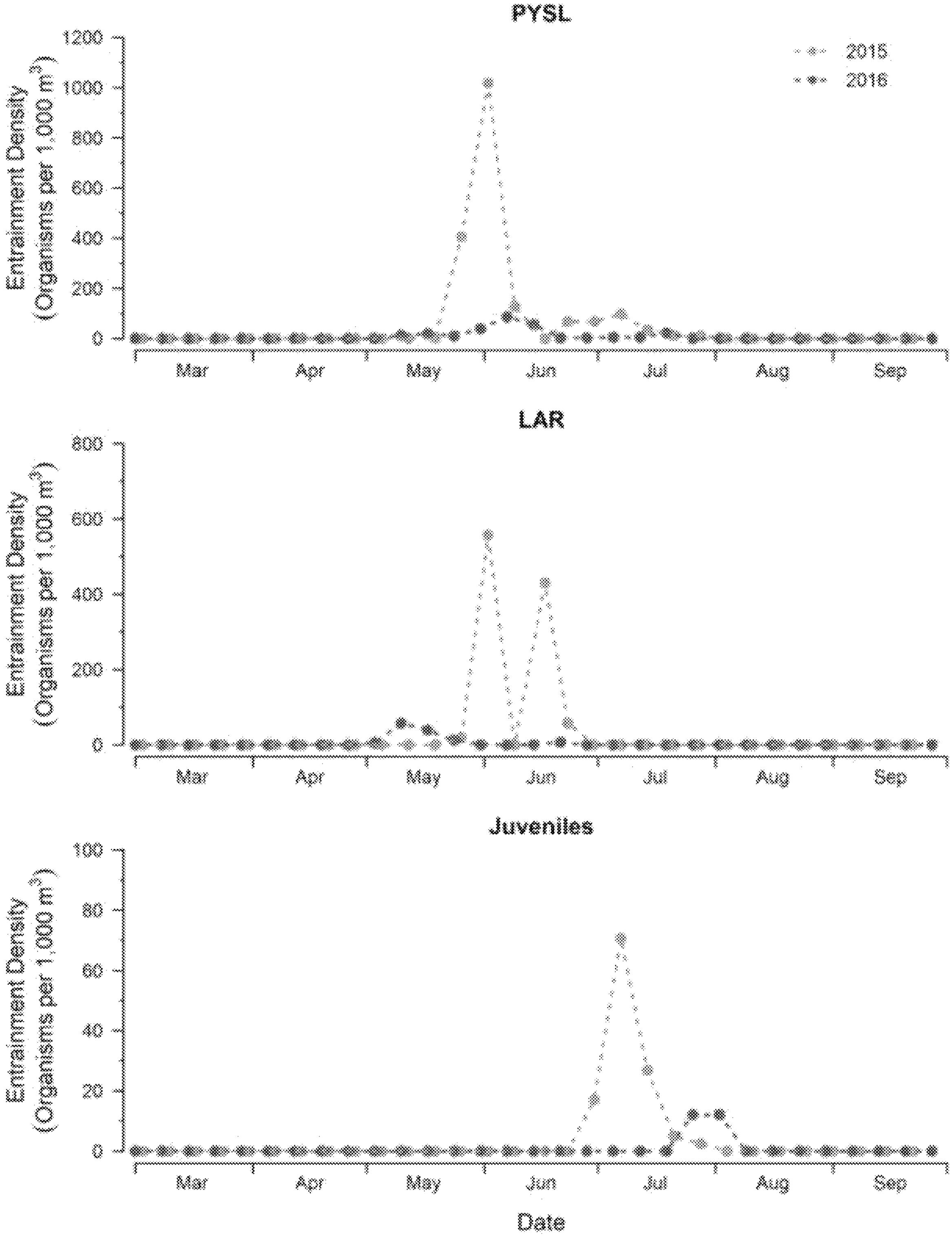


Figure 9-12 Seasonal Pattern of Entrainment of All Shads During 2015 and 2016 Sampling at the LEC.

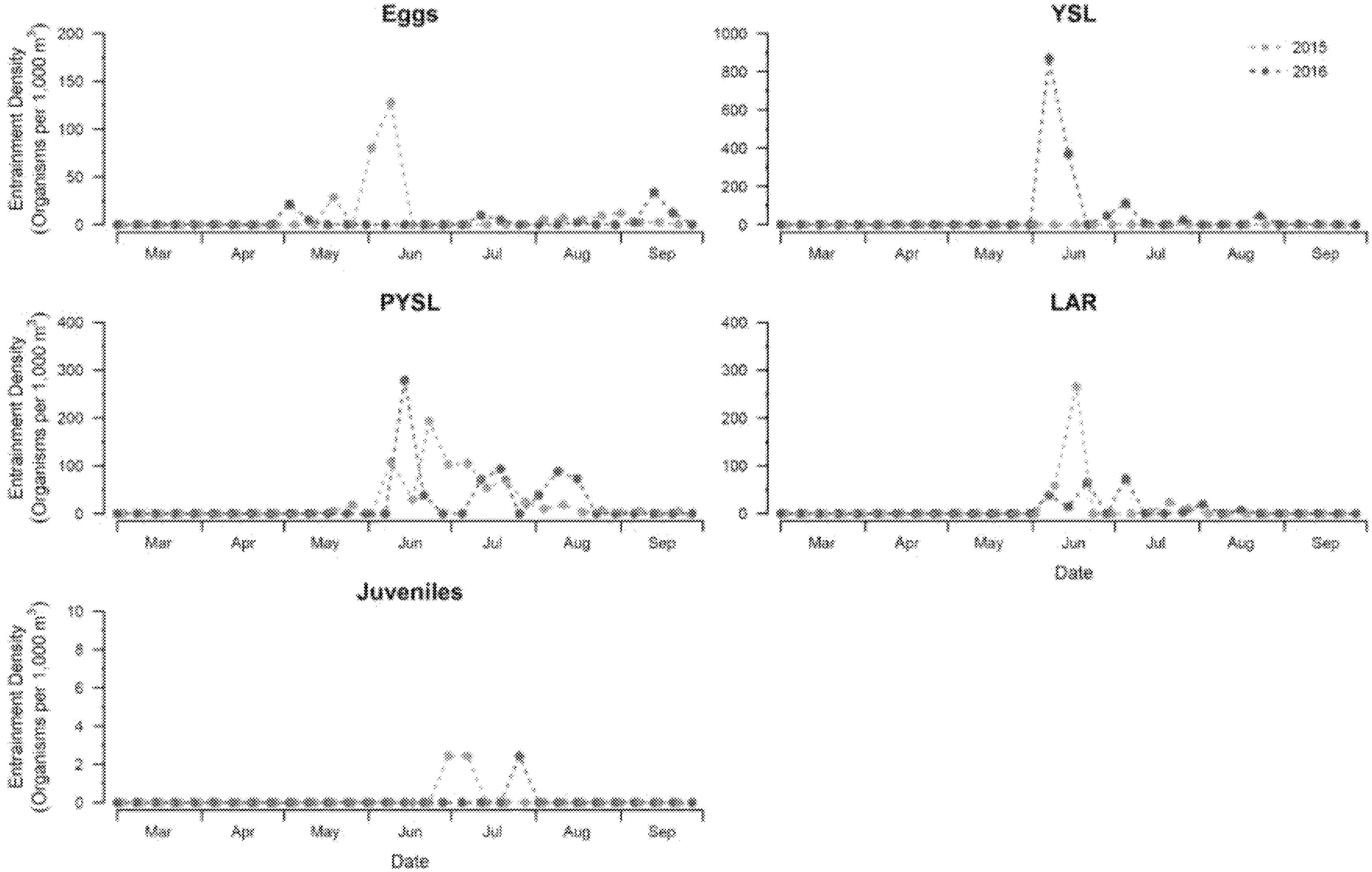


Figure 9-13 Seasonal Pattern of Entrainment of Freshwater Drum During 2015 and 2016 Sampling at the LEC.

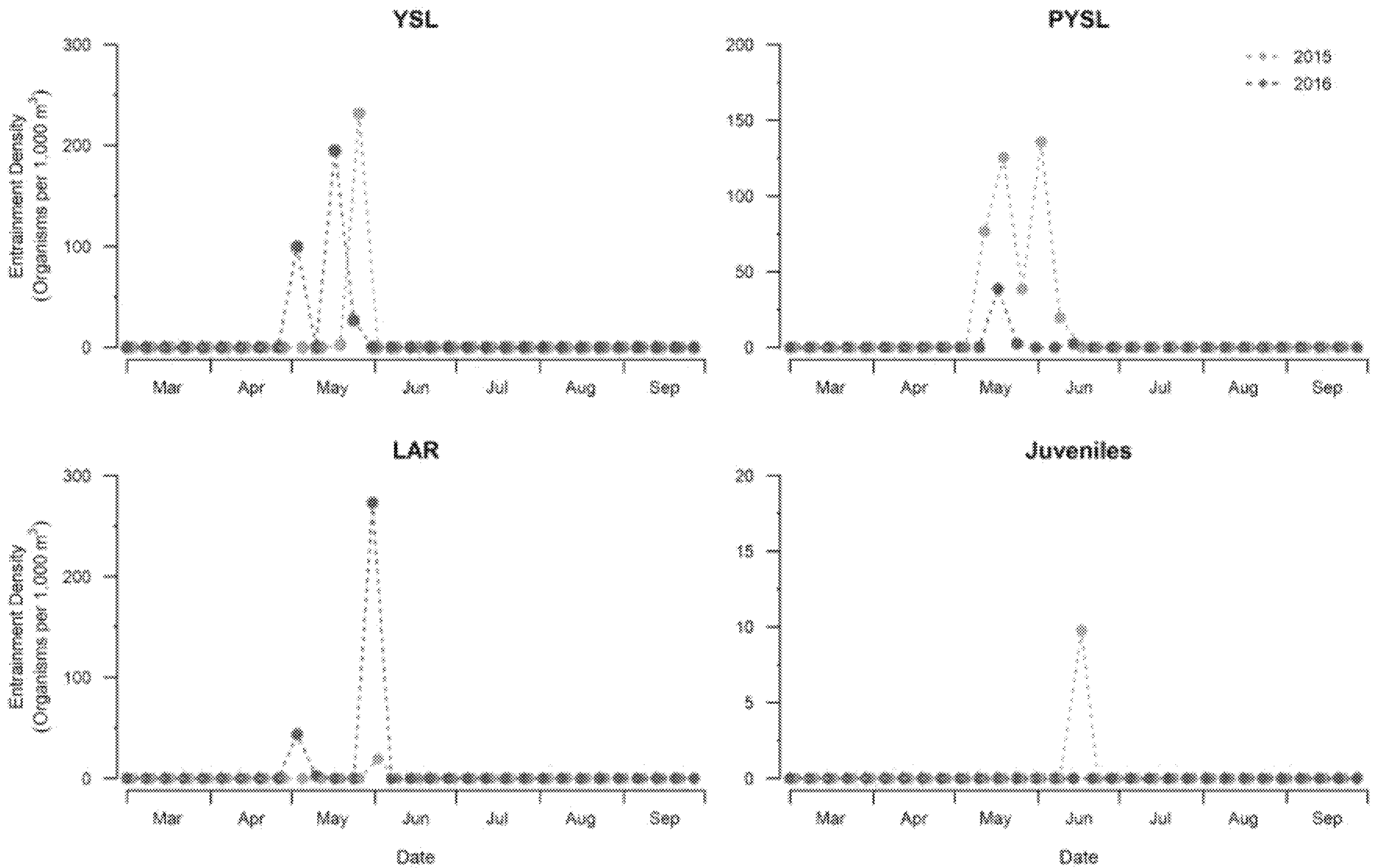


Figure 9-14 Seasonal Pattern of Entrainment of Mooneyes During 2015 and 2016 Sampling at the LEC.

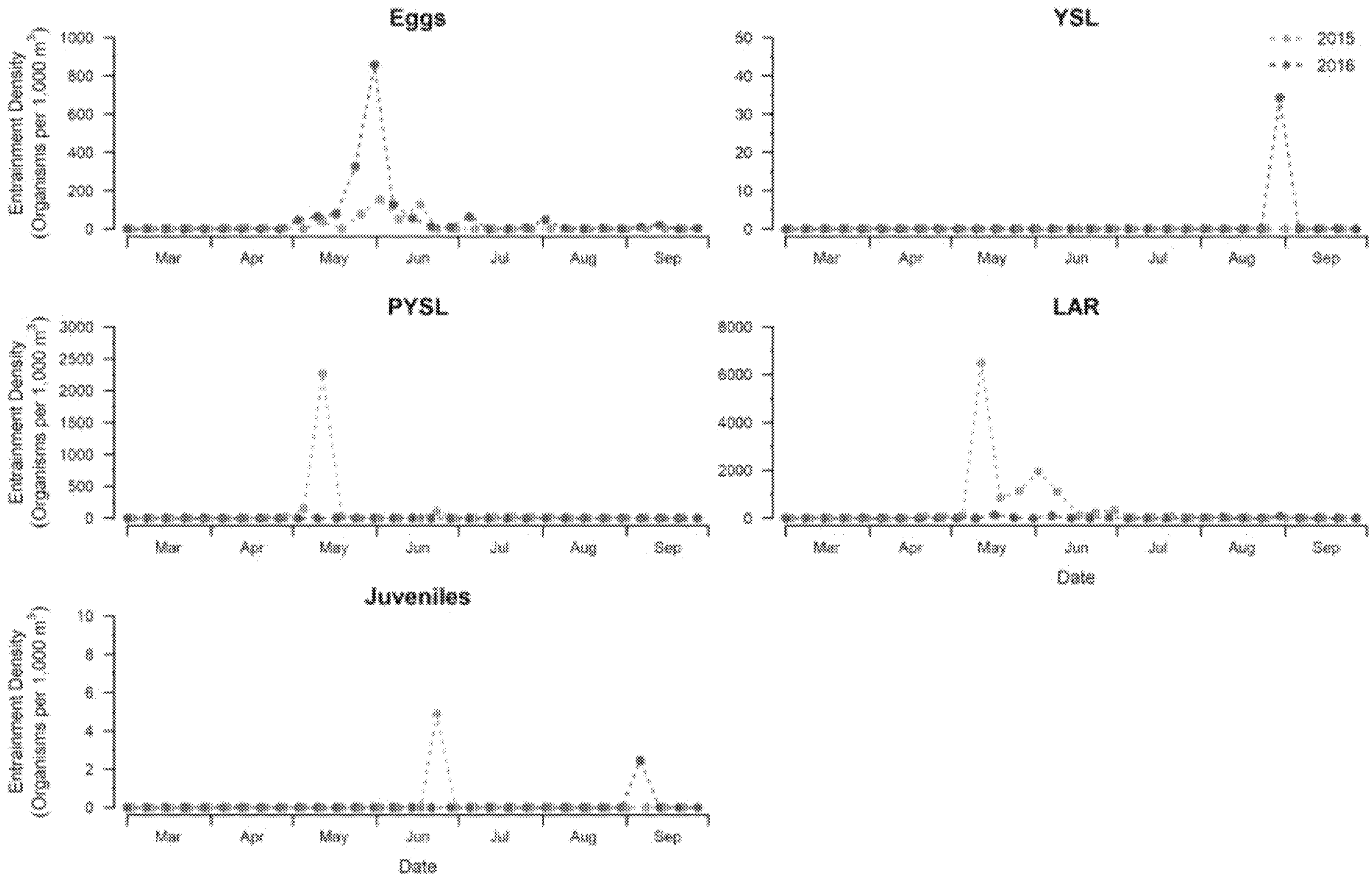


Figure 9-15 Seasonal Pattern of Entrainment of Unidentified Fishes During 2015 and 2016 Sampling at the LEC.

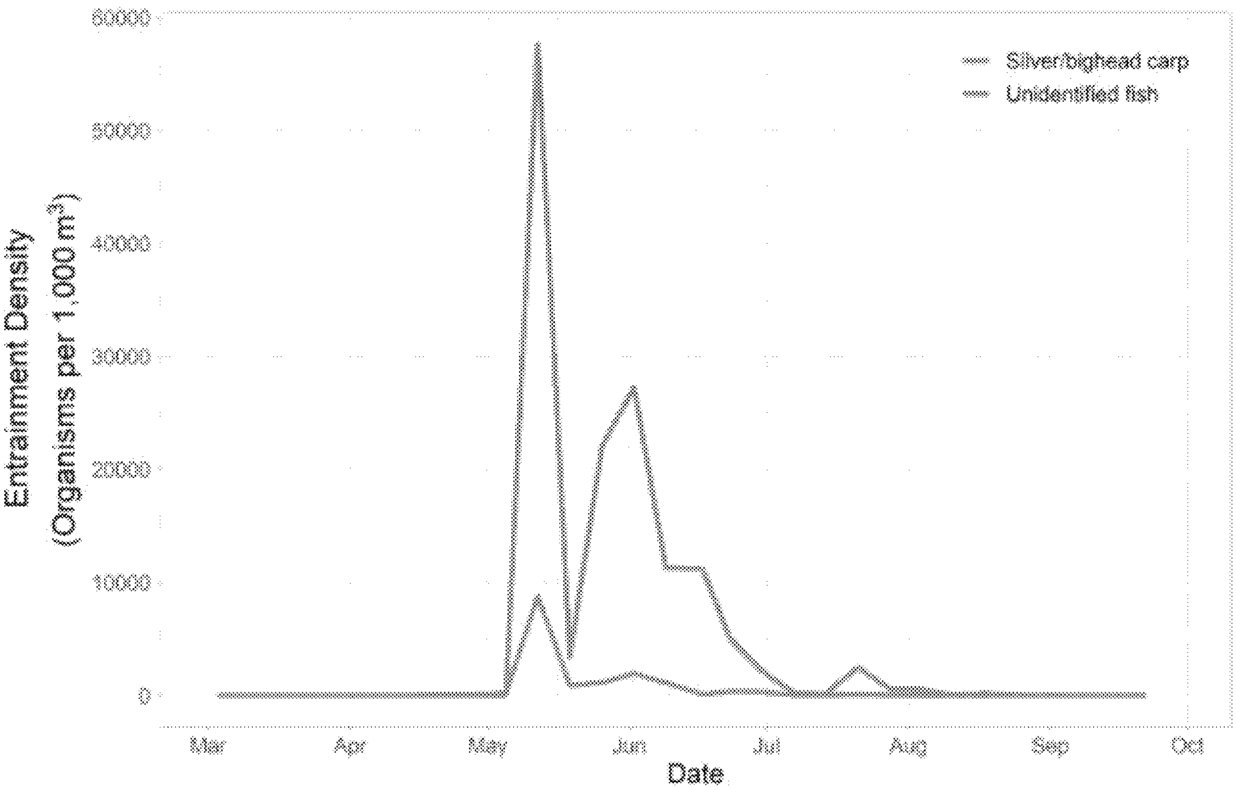


Figure 9-16 Seasonal Pattern of Entrainment of Larvae (All Life Stages) of Silver Carp-Bighead Carp and Unidentified Fishes Collected During 2015 Sampling at the LEC.

9.2.4 Diel Patterns

Nonparametric Kruskal-Wallis rank sum tests (Kruskal and Wallis 1952) were used to determine whether entrainment densities varied among diel sampling intervals for each study year using a significance level (α) of 0.05. Independent tests were performed for each life stage after combining all taxa as well as for major taxonomic groups collected during sampling. Dunn's multiple comparison tests (Dunn 1964) were used to identify which diel sampling intervals differed in density. However, no significant differences in entrainment density were observed among the diel sampling intervals for any development stage during either study year when combining all taxa together (Figure 9-17; Table 9-4) or within major groups (Table 9-4).

No trend was apparent when comparing mean entrainment densities during daytime (06:00-12:00 and 12:00-18:00) and nighttime (18:00-24:00 and 00:00-06:00) sampling intervals across both study years for all taxa combined (Figure 9-18).

Diel patterns of entrainment for each taxon and life stage are presented in Table A-2 in Appendix 9 A and in figures found in Appendix 9 C.

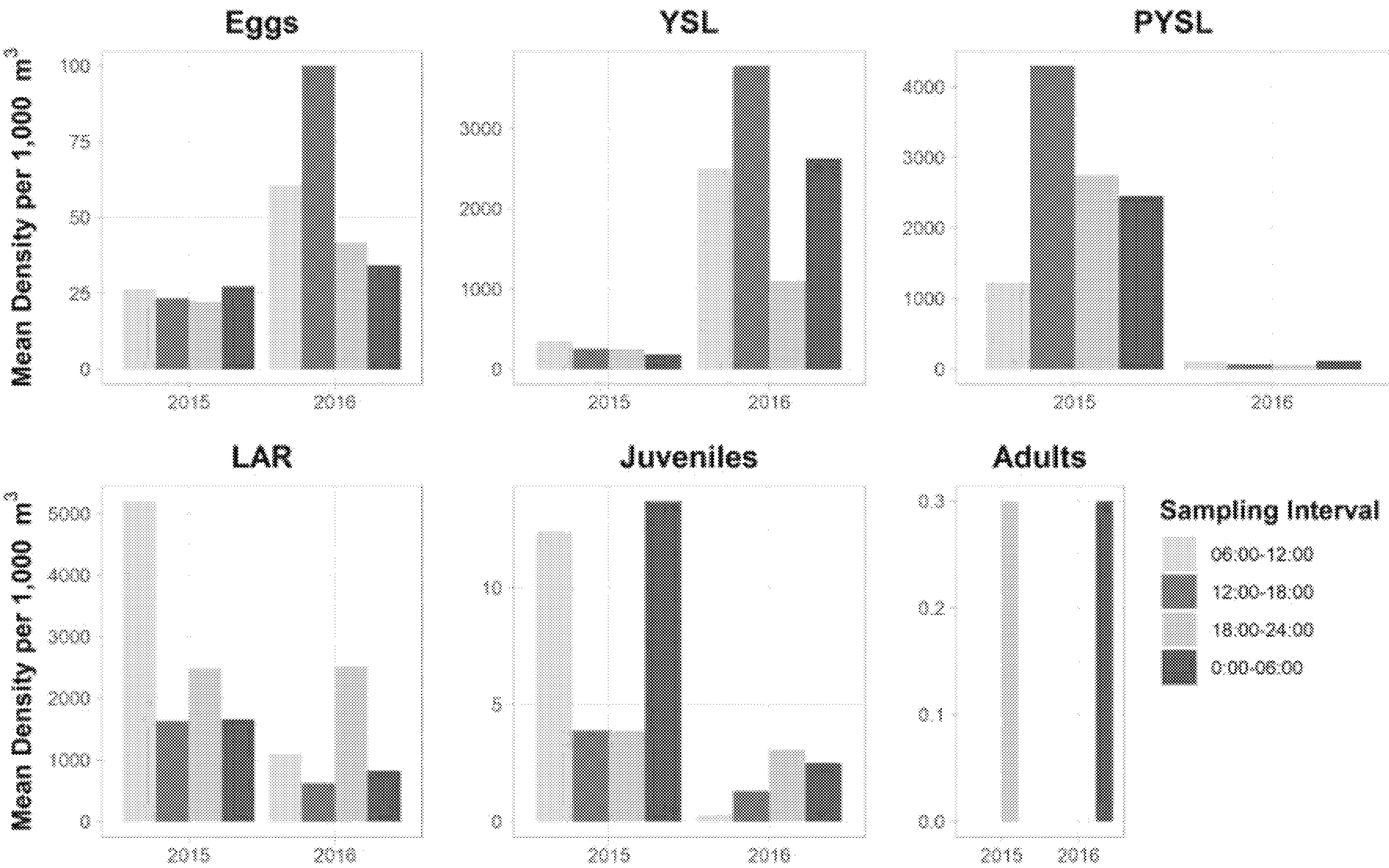


Figure 9-17 Mean Entrainment Density of All Taxa and Development Stages by Diel Periods Sampled at LEC During 2015 and 2016.

Table 9-4 Results of Nonparametric Kruskal-Wallis Tests for Differences in Entrainment Density Among Sampling Intervals by Development Stage for Major Taxonomic Groups Collected During 2015 and 2016 Entrainment Sampling Conducted at LEC.

Taxonomic Group	Development Stage	2015 Study Year		2016 Study Year	
		H	P-value	H	P-value
All fishes combined	Eggs	0.97	0.81	0.92	0.82
	YSL	1.12	0.77	0.15	0.99
	PYSL	0.51	0.92	0.29	0.96
	LAR	0.53	0.91	0.09	0.99
	Juveniles	0.58	0.90	4.67	0.20
	Adults	3.00	0.39	3.00	0.39
Asian carp	Eggs	--	--	3.00	0.39
	YSL	1.41	0.70	0.33	0.95
	PYSL	1.19	0.76	0.47	0.93
	LAR	1.60	0.66	1.65	0.65
	Juveniles	0.67	0.88	--	--
Carpsuckers and buffalos	YSL	5.60	0.13	0.52	0.91
	PYSL	0.23	0.97	0.21	0.98
	LAR	1.10	0.78	1.93	0.59
	Juveniles	3.00	0.39	--	--
Common carp	YSL	3.00	0.39	2.02	0.57
	PYSL	0.43	0.93	5.63	0.13
	LAR	2.02	0.57	2.02	0.57
	Juveniles	3.43	0.33	3.00	0.39
Freshwater drum	Eggs	3.96	0.27	0.99	0.80
	YSL	--	--	1.24	0.74
	PYSL	1.32	0.72	0.03	1.00
	LAR	3.21	0.36	1.79	0.62
	Juveniles	2.02	0.57	3.00	0.39
Mooneyes	YSL	0.59	0.90	0.43	0.93
	PYSL	1.83	0.61	3.68	0.30
	LAR	3.00	0.39	0.63	0.89
	Juveniles	3.00	0.39	--	--
Minnows	YSL	3.00	0.39	2.17	0.54
	PYSL	0.83	0.84	5.89	0.12
	LAR	3.42	0.33	2.38	0.50
	Adults	3.00	0.39	--	--
Shads	PYSL	0.01	1.00	3.46	0.33
	LAR	0.96	0.81	0.35	0.95
	Juveniles	0.72	0.87	4.10	0.25
All remaining fishes	Eggs	0.97	0.81	0.48	0.92
	YSL	0.70	0.87	1.98	0.58
	PYSL	0.72	0.87	0.51	0.92
	LAR	0.29	0.96	0.45	0.93
	Juveniles	1.65	0.65	4.09	0.25
	Adults	--	--	3.00	0.39

-- No specimens collected during study year

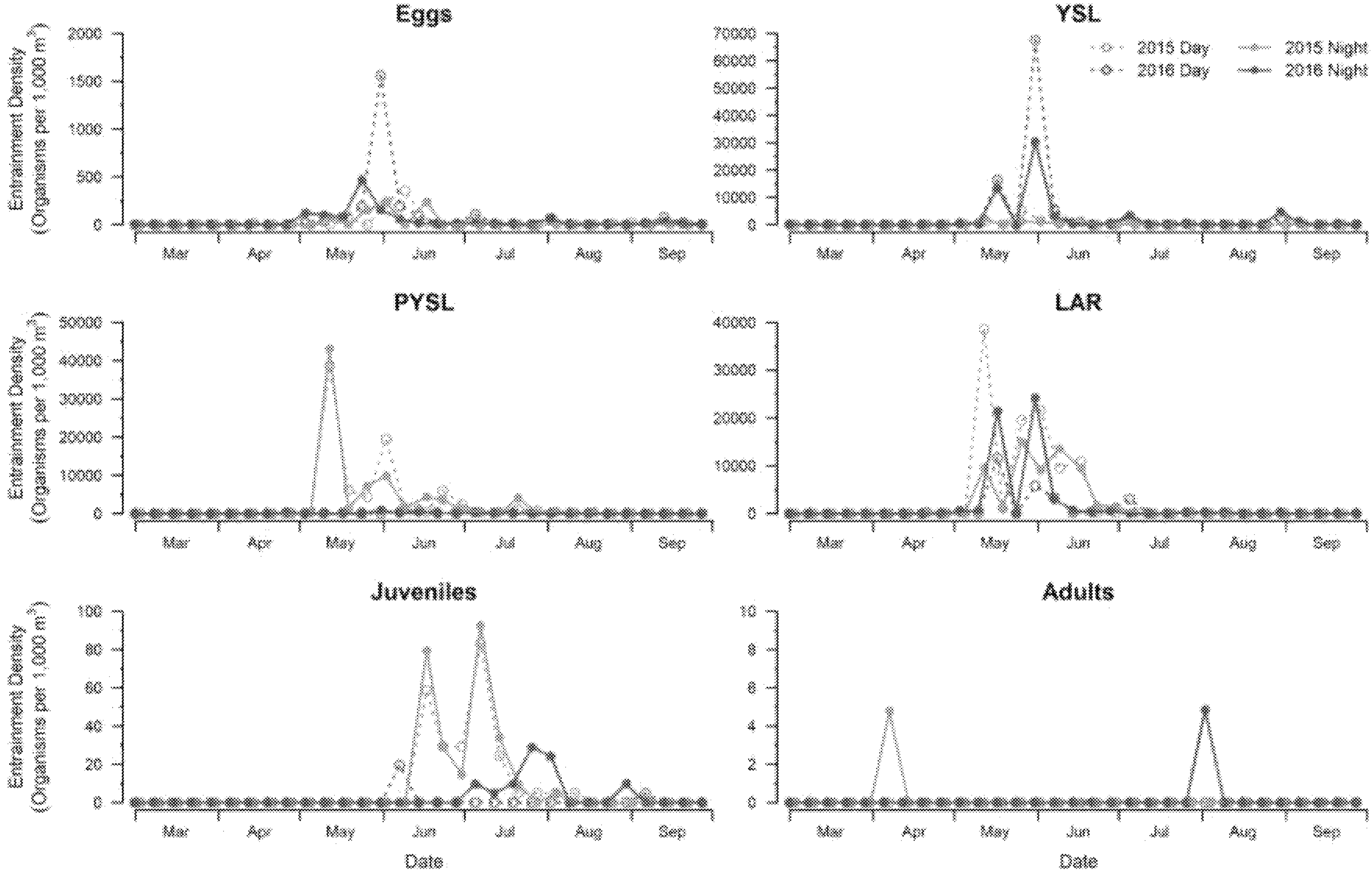


Figure 9-18 Daytime and Nighttime Entrainment Densities of All Taxa and Development Stages During 2015 and 2016 Sampling at LEC.

9.2.5 Length Distributions

A combined total of 7,924 and 7,027 YSL, PYSL, juvenile and adult specimens were measured for length during 2015 and 2016, respectively. Length distributions for each life stage are presented as boxplots in Figure 9-19 for taxonomic groups that were collected in relative abundance during at least one study year. Juveniles collected during 2016 tended to be larger than those collected in 2015. YSL of Asian carp and carpsuckers and buffalos and PYSL of Asian carps, carpsuckers and buffalos, common carp, and other carps and minnows collected during 2016 also had a higher frequency of larger individuals during 2016 in comparison to 2015. No YSL of freshwater drum were collected during 2015. YSL of mooneyes and all remaining taxa and PYSL of freshwater drum, mooneyes, shads, and all remaining taxa collected during 2015 tended to be larger than those collected in 2016.

Length distributions of each taxon and life stage measured during entrainment sampling are presented in Table A-3 in Appendix 9 A and in figures found in Appendix 9 D.

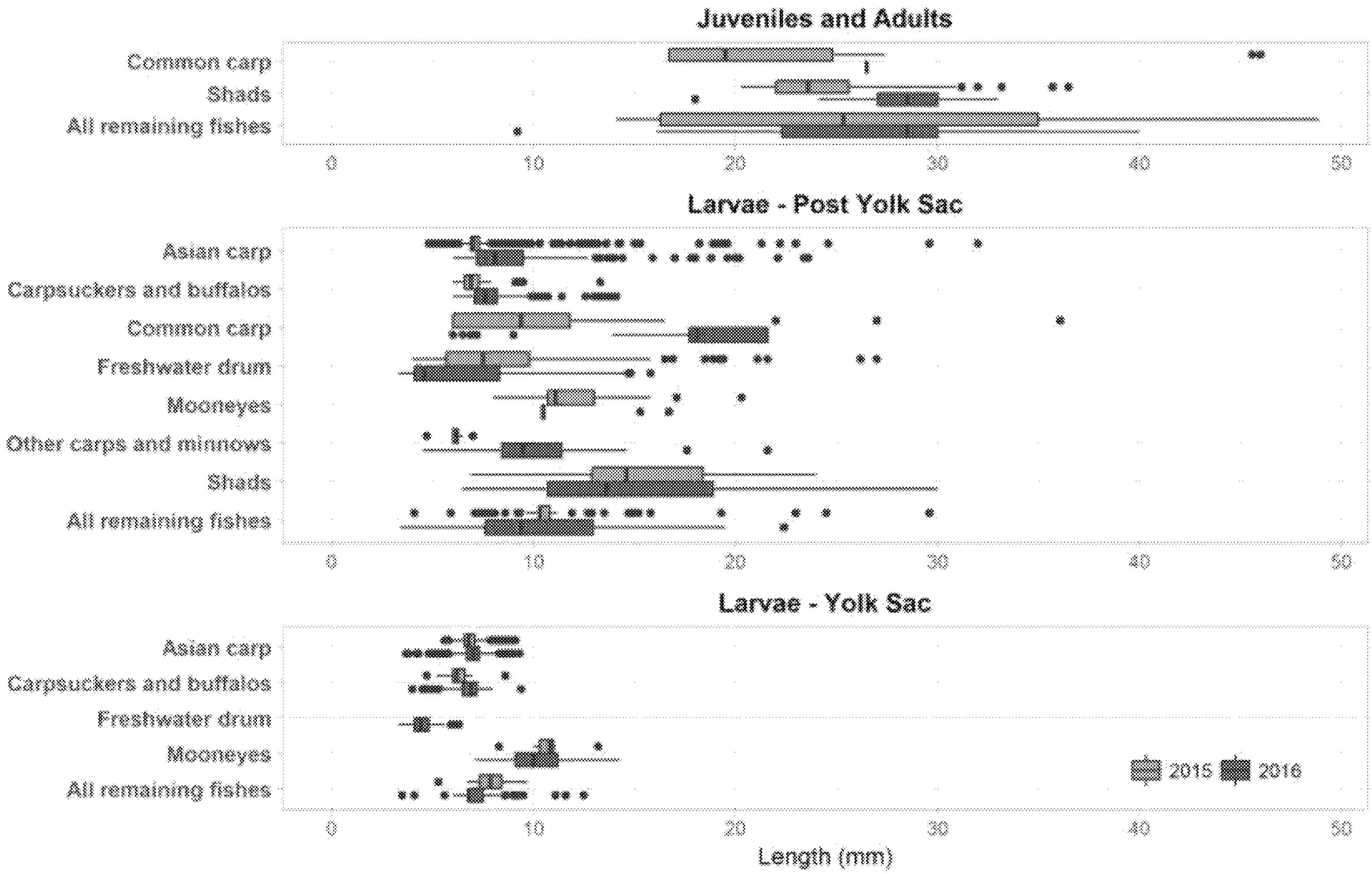


Figure 9-19 Length Boxplots of Major Taxa by Development Stage Collected During 2015 and 2016 Entrainment Sampling at the LEC.

Colored rectangles represent the interquartile range (25th to 75th percentile) of measured lengths with black vertical lines indicating the median value. Horizontal lines or "whiskers" either extend to the minimum and maximum values or to a length of 1.5 times the interquartile range with dots considered outlying values.

9.2.6 Interannual Variation

In comparison to the 2016 study year, entrainment sampling during 2015 was conducted over one fewer sampling event, which resulted in a difference in the total cooling water sampled between study years of 319 m^3. Yet, the total number of organisms collected in entrainment samples during 2015 was 41 percent greater than the number collected during 2016. The large difference in entrainment may be explained partially by interannual variability in river flows as the mean flow calculated across the 2015 study year (127,917 cfs) using data collected at Hermann Gage was approximately 20 percent greater than the 2016 study year mean (106,806 cfs). Furthermore, the total volume of cooling water withdrawn at the LEC during the 2015 study year (278,846 MG) was approximately 7 percent greater than during the 2016 study year (260,067 MG) with even greater differences (11-26 percent) observed during months of peak entrainment (May-July).

The reduction in total entrainment observed during 2016 (20,718 fewer specimens) was nearly entirely explained by large decreases in the number of specimens of Asian carp in the genus *Hypophthalmichthys* (19,417 fewer specimens), which included silver and bighead carp, and shads primarily identified as gizzard shad (1,071 fewer specimens). Studies conducted in the LMOR (Schrank et al. 2001, Deters et al. 2013) and lower Illinois River (DeGrandchamp et al. 2007) have reported increased spawning of Asian carp species under high flows once water temperatures rise above an optimum of 71.6 °F. Thus, river conditions during 2015 may have favored these taxa and increased their productivity as similar decreases were not observed for other taxa in 2016. In contrast, counts of most other relatively abundant taxa increased during 2016 or were relatively similar to counts made in 2015. However, increased counts of some taxa in 2016 may have resulted from a large reduction (6,091 fewer specimens) in unidentified larval specimens in comparison to the previous year. Additional experience as well as the implementation of the concurrent river ichthyoplankton sampling program likely increased the confidence of investigators when making taxonomic identications and contributed to the decline in unidentified specimens during 2016.

A similar mechanism may partially account for the large increase in YSL observed during 2016 (28,673 additional specimens) as many fewer larvae of indistinguishable development stage were collected (17,772 fewer specimens). The large decline in PYSL in 2016 (31,987 fewer specimens) was mostly accounted for by the reduced abundance of silver carp or bighead carp PYSL (29,926 fewer specimens). Peak periods of entrainment were relatively similar between both study years.

Past entrainment sampling at the LEC was conducted weekly from 19 July to 29 August, 1974 and from 3 April to 3 June, 1975 using river ichthyoplankton tows near the intake (EEHI 1976a). The sampling location of the past study was designed to characterize the fish eggs and larvae susceptible to entrainment instead of actual entrainment, which limits the ability to make comparisons to the present study. The period of peak entrainment occurred from early May to early June, which was similar to peak periods observed during 2015 and 2016 sampling, which occurred from mid-May to early or mid-June.

The most abundant taxa observed among larval specimens collected during the 1974 – 1975 study were minnows other than common carp, herrings, and mooneyes, which accounted for approximately 55, 17, and 16 percent of larval specimens, respectively. After excluding Asian carps and unidentifiable larvae from the 2015 and 2016 collections, these taxa accounted for between 64 and 73 percent of remaining larvae as freshwater drum, carpsuckers, and buffalos were also relatively abundant. Thus, the composition of entrained ichthyoplankton at the LEC has changed considerably in the intervening 40 years, particularly as Asian carps have successfully invaded during the last decade. No estimate of total entrainment was made during the 1974 – 1975 study period.

9.2.7 Estimated Numbers Entrained

Approximately 6 billion fish eggs, larvae, juveniles, and adults were estimated to have been entrained at the LEC during 2015 (Table 9-5) based on observed organism densities during sampling and measured cooling water flows. Larvae accounted for greater than 99 percent of all estimated entrainment, whereas Asian carp of all life stages represented 84 percent of the estimate. Unidentified fishes, minnows, shads including gizzard shad, freshwater drum, carpsuckers and buffalos, goldeye, and common carp accounted for the majority of the remaining taxa estimated to have been entrained at LEC during 2015. Excluding Asian carps (bighead carp, silver carp, and grass carp) and common carp, which are introduced species frequently considered to be nuisance organisms, reduces the total estimate to approximately 981 million organisms entrained at LEC during 2015.

Approximately 3.6 billion fish eggs, larvae, juveniles, and adults were estimated to have been entrained at the LEC during 2016 (Table 9-5). Larvae accounted for approximately 98 percent of all estimated entrainment, whereas Asian carps of all life stages represented 86 percent of the estimate. Minnows, freshwater drum, unidentified fishes, carpsuckers and buffalos, gizzard shad, mooneyes, and common carp accounted for the majority of the remaining taxa estimated to have been entrained at the LEC during 2016. Excluding carp species reduces the total estimate of entrainment at the LEC during 2016 to approximately 505 million organisms.

Mortality of entrained organisms was assumed to be 100 percent for the purposes of item *iii* required under § 122.21(r)(9) of the § 316(b) Rule as outlined at the beginning of this Section.

Table 9-5 Estimated Entrainment of All Fish Taxa and Development Stages at the LEC During 2015 and 2016.

2015 Study Year								
Taxon	Eggs	YSL	PYSL	LAR	Juveniles	Adults	Total	Percent
Silver and bighead carp	--	254,677,030	2,510,989,879	2,410,718,219	928,154	0	5,177,313,282	83.9
Unidentified fishes	18,471,469	0	78,445,038	432,703,234	192,263	0	529,812,004	8.6
Minnow family	--	896,727	20,181,272	160,610,417	0	0	181,688,416	2.9
Gizzard shad	--	0	70,051,918	30,043,439	5,116,653	0	105,212,010	1.7
Freshwater drum	11,593,288	0	31,390,672	15,418,477	206,034	0	58,608,471	1.0
Carpsuckers and buffalos	--	9,872,817	9,633,524	3,951,733	0	0	23,458,074	0.4
Goldeye	--	9,057,189	13,396,761	0	415,881	0	22,869,831	0.4
Shads	--	0	3,879,985	13,274,778	0	0	17,154,763	0.3
Grass carp	--	10,904,771	4,531,973	0	0	0	15,436,744	0.3
Common carp	--	190,746	7,572,480	1,313,403	2,038,128	0	11,114,757	0.2
Buffalos	--	3,850,161	2,035,798	547,906	192,263	0	6,626,128	0.1
Carpsuckers	--	3,329,932	2,252,837	0	0	0	5,582,769	0.1
Minnows group 2	--	0	3,624,510	0	0	0	3,624,510	0.1
Sucker family	--	0	68,315	3,253,836	0	0	3,322,151	0.1
Walleye	--	0	2,185,944	69,094	0	0	2,255,038	<0.1
Redhorse suckers	--	693,372	964,118	271,131	0	0	1,928,621	<0.1
Mooneyes (*Hiodon* sp.)	--	0	1,093,884	766,179	0	0	1,860,063	<0.1
White sucker	--	138,794	1,300,956	211,172	0	0	1,650,922	<0.1
Sunfish family	--	0	1,163,421	0	93,609	0	1,257,030	<0.1
Crappies	--	0	0	0	842,856	0	842,856	<0.1
Channel catfish	--	0	182,225	101,348	288,917	0	572,490	<0.1
Silver carp	--	0	342,699	0	103,448	0	446,147	<0.1
Shortnose gar	--	0	0	439,506	0	0	439,506	<0.1
White bass	--	0	204,997	0	192,587	0	397,584	<0.1
Walleye and sauger	--	0	298,494	0	0	0	298,494	<0.1
White crappie	--	0	192,263	0	0	0	192,263	<0.1
Minnows group 5	--	0	101,027	0	0	0	101,027	<0.1
North American catfish family	--	0	100,259	0	0	0	100,259	<0.1
Blue catfish	--	0	99,206	0	0	0	99,206	<0.1
Minnows group 6	--	0	93,188	0	0	0	93,188	<0.1

Shoal chub	--	0	0	0	0	42,823	42,823	<0.1
Estimated Annual Entrainment	**30,064,757**	**293,611,539**	**2,766,377,643**	**3,073,693,872**	**10,610,793**	**42,823**	**6,174,401,427**	**100.0**
2016 Study Year								
Taxon	Eggs	YSL	PYSL	LAR	Juveniles	Adults	Total	Percent
Silver and bighead carp	579,767	2,043,106,870	24,410,968	842,537,592	0	0	2,910,635,197	80.0
Minnow family	--	96,628	184,298	219,329,971	0	0	219,610,897	6.0
Grass carp	--	199,694,463	8,528,181	5,811,316	0	0	214,033,960	5.9
Freshwater drum	3,265,346	50,658,340	25,387,946	8,226,487	93,141	0	87,631,260	2.4
Unidentified fishes	52,147,705	1,149,306	87,684	14,517,986	85,709	0	67,988,390	1.9
Carpsuckers and buffalos	--	12,191,080	13,883,276	27,830,575	0	0	53,904,931	1.5
Carpsuckers	--	14,215,373	4,201,245	1,536,489	0	0	19,953,107	0.6
Gizzard shad	--	0	8,448,456	2,496,413	942,770	0	11,887,639	0.3
Mooneyes (*Hiodon* sp.)	--	923,121	953,847	9,502,543	0	0	11,379,511	0.3
Buffalos	--	6,562,021	2,275,527	0	0	0	8,837,548	0.2
Common carp	--	1,975,584	4,201,595	485,010	316,201	0	6,978,390	0.2
Goldeye	--	5,787,571	60,531	69,988	0	0	5,918,090	0.2
Minnows group 2	--	1,663,955	1,109,524	681,191	0	0	3,454,670	0.1
White bass	--	2,383,131	0	0	0	0	2,383,131	0.1
Mooneye	--	1,662,044	86,995	139,979	0	0	1,889,018	0.1
Sunfishes (*Lepomis* sp.)	--	184,262	1,281,457	0	179,175	0	1,644,894	0.1
Blue sucker	--	761,188	304,066	565,090	0	0	1,630,344	<0.1
White sucker	--	0	139,979	842,746	0	0	982,725	<0.1
Sucker family	--	0	0	962,201	0	0	962,201	<0.1
Blue catfish	--	90,312	283,569	277,026	168,509	0	819,416	<0.1
Shads	--	0	0	598,978	0	0	598,978	<0.1
Redhorse suckers	--	67,213	341,327	0	0	0	408,540	<0.1
Walleye and sauger	--	138,520	264,895	0	0	0	403,415	<0.1
Minnows group 6	--	0	238,147	139,979	0	0	378,126	<0.1
Sunfish family	--	0	262,808	0	0	0	262,808	<0.1
Minnows group 4	--	92,784	159,218	0	0	0	252,002	<0.1
Minnows group 3	--	0	205,997	0	0	0	205,997	<0.1
Darter (*Etheostoma* sp.)	--	68,488	127,073	0	0	0	195,561	<0.1
Logperch	--	70,999	61,655	62,873	0	0	195,527	<0.1
Catfish (*Ictalurus* sp.)	--	0	0	0	184,298	0	184,298	<0.1

Crappies	--	0	143,969	0	0	0	143,969	<0.1
Western mosquitofish	--	0	0	0	0	95,745	95,745	<0.1
North American catfish family	--	92,907	0	0	0	0	92,907	<0.1
Channel catfish	--	0	0	0	92,239	0	92,239	<0.1
Walleye	--	0	71,009	0	0	0	71,009	<0.1
Paddlefish	--	0	0	70,130	0	0	70,130	<0.1
Darter (*Percina* sp.)	--	68,506	0	0	0	0	68,506	<0.1
Redhorses/white sucker	--	0	67,213	0	0	0	67,213	<0.1
Estimated Annual Entrainment	**55,992,818**	**2,343,704,666**	**97,772,455**	**1,136,684,563**	**2,062,042**	**95,745**	**3,636,312,289**	**100.0**

9.3 SIGNIFICANCE OF ENTRAINMENT

Asian carp species, including bighead carp, silver carp, and grass carp, were introduced to the United States by natural resource agencies and aquaculturists in 1970s as intended biological tools (Wanner and Klumb 2009). After escaping their original places of introduction, they subsequently have spread throughout the Mississippi River basin (Sullivan 2016). Due to their wide tolerance of environmental conditions and life history characteristics, including rapid growth, early maturation, high fecundity, and protracted spawning, Asian carps have been highly successful in establishing populations in numerous river systems, including the LMOR (Wanner and Klumb 2009, Sullivan 2016). These fishes are generally regarded as nuisance species that have the potential to cause ecological harm to native fishes and other aquatic organisms as they expand throughout the Missouri River due to their ability to alter water quality and obtain high densities (Freedman et al. 2012).

Asian carps accounted for approximately 8.3 billion of the 9.8 billion fish eggs, larvae, juveniles, and adults estimated to have been entrained at the LEC during the 2015 and 2016 study years. The dominance of Asian carps in entrainment samples likely can be attributed to life history traits as they are known to have high fecundity rates with females producing hundreds of thousands of eggs that develop into larvae while drifting in turbulent waters (Wanner and Klumb 2009, George et al. 2017), which may make them particularly susceptible to entrainment at the LEC CWIS. Adult Asian carps have not been caught in high abundance during monitoring efforts conducted in the river near the LEC, which may indicate that these species have not been effectively sampled or that they are present at higher densities in other habitats in or near the river but distant from the LEC.

Excluding Asian carps, the remaining 1.5 billion fishes estimated to have been entrained during the two study years consisted primarily of fishes identified as minnows including common carp, as well as freshwater drum, shads primarily represented by gizzard shad, carpsuckers and buffalos, goldeyes or mooneyes, or unidentified fishes. Based on past and recent monitoring efforts (EEHI 1976b, Ameren 2002), gizzard shad and freshwater drum are among the most abundant taxa present in the LMOR near the LEC, which increases the probability of entrainment of their larvae. The pelagic egg of freshwater drum, a broadcast spawner like Asian carp, is also susceptible to entrainment. Entrainment of remaining taxa likely was associated with their distribution and abundance near the LEC as a high diversity of minnows occur in the LMOR and river carpsucker, smallmouth buffalo, and goldeye have been collected in high numbers during past monitoring efforts (Ameren 2002).

Recreationally valuable game fish, including species of catfish, white bass, walleye, and sauger, as well as panfish, such as sunfishes and crappies, collectively represented less than one percent of the total entrainment estimate after excluding Asian carp. These taxa have life history traits that likely reduce their susceptibility to entrainment as all species produce demersal, adhesive eggs as opposed to buoyant eggs that drift in the water column. Furthermore, channel catfish and fishes in the sunfish family deposit eggs in nests and guard young for a period of time following hatching.

No threatened or endangered species known to occur in the LMOR, including the federal and state-endangered pallid sturgeon, were identified within entrainment samples collected at the LEC during 2015 and 2016.

Additional information on the biological community in the LMOR near the LEC is provided in the *§ 122.21(r)(4) Source Water Baseline Characterization Data* submittal report.

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